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1.0 INTRODUCTION

This document analyzes the benefits and impacts associated with amending the *San Francisco Bay Plan* ("Bay Plan," BCDC 1969, as amended) to allow the placement of dredged material in Bay waters for beneficial reuse purposes. The proposed amendment would revise dredging policies to more specifically address beneficial reuse projects to create, restore, and/or enhance habitat in the Bay. "Beneficial reuse," for the purposes of this Amendment, is limited to creation or enhancement of habitat.

Section 1.1 describes existing policies in the Bay Plan (BCDC 1969, as amended) related to dredged material placement and how those policies would be changed by the proposed Bay Plan Amendment that is the subject of this document.

The analysis has been prepared at a general, programmatic level for planning purposes. Where appropriate, specific sites for creation or enhancement of habitat are discussed but, for the most part, the analysis is not site-specific. In the future, when specific projects are proposed for habitat creation or enhancement by placing dredged material in the Bay, they will be subject to project-specific environmental review under the California Environmental Quality Act (CEQA). The San Francisco Bay Conservation and Development Commission is a CEQA equivalent agency. The types of studies that would generally be required for these site-specific analyses are listed in Chapter 9.

1.1 EXISTING POLICIES

The existing Bay Plan policies encourage beneficial use of dredged material, but the emphasis is on reuse in areas outside the Commission's Bay and certain waterway jurisdictions. In particular, Policy 2 states that material can be disposed in the Bay only if other options are not feasible. The proposed Port of Oakland Middle Harbor habitat enhancement project highlighted these issues. The Commission gave direction to staff to address them in the context of the comprehensive amendments of the Commission's dredging policies. The amendments would clarify the policies that the Commission should use to consider applications for reuse of dredged material in Bay habitat projects, as distinct from dredged material disposal at the existing in-Bay disposal sites. Specific policy language would be included for Commission approval of such projects and inclusion of permit conditions in approvals.

The Marshes and Mudflats policies state the importance of protecting and expanding Bay marsh and mudflat areas. In particular, Policy 3, states that dredged material may be used in certain areas to create new marshes. The policy is silent on subtidal habitat.

The Fish and Wildlife policies talk about the importance of preserving the surface area and volume of the Bay and that marshes and mudflats should be preserved.

The McAteer-Petris Act does not specifically address use of dredged material for habitat purposes in the Bay. The Act regulates disposal of dredged material or any other material as the placement of fill. The Act's fill policies state, in part, that fill should be approved only for a water-oriented use, unless it is a small amount of fill for public access or establishing a permanent shoreline. The fill should be the minimum amount necessary, have no alternative upland location, and the project benefits must outweigh the detriments. The Commission can also approve fill that is necessary to the health, safety, and welfare of the entire Bay Area. The McAteer-Petris Act requires that projects must be consistent with the applicable policies of the Commission's Bay Plan.

The sections below discuss current Bay Plan policies that are pertinent to the placement of dredged material in the Bay, or for habitat projects, or both. The bold text in the policies below has been added for emphasis pertinent to this analysis.

1.1.1 Policies on Marshes and Mudflats

The policies on Marshes and Mudflats are described on pages 12-13 of the Bay Plan.

1. Marshes and mudflats should be maintained to the fullest possible extent to conserve fish and wildlife and to abate air and water pollution. Filling and diking that eliminate marshes and mudflats should therefore be allowed only for purposes providing substantial public benefits and only if there is no reasonable alternative. Marshes and mudflats are an integral part to the Bay tidal system and therefore should be protected in the same manner as open water areas.

2. Any proposed fills, dikes, or piers should be thoroughly evaluated to determine their effects on marshes and mudflats, and then modified as necessary to minimize any harmful effects.

3. To offset possible additional losses of marshes due to necessary filling and to augment the present marshes, (a) former marshes should be restored when possible through removal of existing dikes, (b) **in areas selected on the basis of competent ecological study, some new marshes should be created through carefully placed lifts of dredged spoils,** and (c) the quality of existing marshes should be improved by appropriate measures whenever possible.

1.1.2 Policies on Fish and Wildlife

The policies on Fish and Wildlife are on page 9 of the Bay Plan.

1. The benefits of fish and wildlife in the Bay should be insured for present and future generations of Californians. Therefore, to the greatest extent feasible, the remaining marshes and mudflats around the Bay, the remaining water volume and surface area of the Bay, and adequate fresh water inflow into the Bay should be maintained.

2. Specific habitats that are needed to prevent the extinction of any species, or to maintain or increase any species that would provide substantial public benefits, should be protected, whether in the Bay or on the shoreline behind dikes. Such areas on the shoreline are designated as Wildlife Areas on the [Bay] Plan maps.

1.1.3 Policies on Dredging

The policies on Dredging are on pages 22-23 of the Bay Plan.

2. **Disposal of dredged materials should be encouraged in non-tidal areas where the materials can be used beneficially, or in the ocean. Disposal in tidal areas of the Bay should be authorized when the Commission can find that: (a) the applicant has demonstrated that non-tidal and ocean disposal is infeasible because there are no alternate sites available or likely to be available for use in a reasonable period, or the cost of disposal at alternate sites is prohibitively expensive; (b) disposal would be at a site designated by the Commission;** (c) the quality and volume of the material to be disposed is consistent with the advice of the San Francisco Bay Regional Water Quality Control Board; and (d) the period of disposal is consistent with the advice of the Department of Fish and Game and the National Marine Fisheries Service.

4. To ensure adequate capacity for necessary Bay dredging projects and to protect Bay natural resources, acceptable non-tidal disposal sites should be secured and ocean disposal sites designated. **Further, disposal projects should maximize use of dredged material as a resource, such as creating, enhancing, or restoring tidal and managed wetlands**, creating and maintaining levees and dikes, providing cover and sealing material for sanitary landfills, **and filling at approved construction projects**.

1.2 PROPOSED NEW BAY PLAN POLICIES REGARDING REUSE OF DREDGED MATERIAL

Below is the text of proposed new Bay Plan policies specific to the reuse of dredged material for habitat creation, restoration, and enhancement in the Bay.

3.~~2.~~ ~~Disposal of d~~**Dredged materials should, if feasible, be reused** or disposed ~~encouraged~~ outside the Commission's Bay and certain waterway jurisdictions~~where the materials can be used beneficially,~~. Disposal in the Commission's Bay and certain waterway jurisdiction should be authorized for projects where disposal outside the Commission's Bay and certain waterway jurisdiction is infeasible and where the dredged material will not be beneficially used in approved fill projects only when the Commission makes all the following findings: (a) the volume to be disposed is consistent with applicable dredger disposal allocations and disposal site limits adopted by the Commission by regulation; (b) disposal would be at a site designated by the Commission; (c) the quality of the material disposed of is consistent with the advice of the San Francisco Bay Regional Water Quality Control Board and the inter-agency Dredged Material Management Office (DMMO); and (d) the period of disposal is consistent with the advice of the California Department of Fish and Game, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service.

11. A project that uses dredged material to create, restore or enhance Bay natural resources should be approved only if:

(a) The Commission determines, based on detailed site-specific technical studies appropriate to the size and potential impacts of the project and consistent with the advice of the California Department of Fish and Game, the National Marine Fisheries Service, and the U.S. Fish and Wildlife Service, that: (1) the project would, in relationship to the project size, substantially improve habitat for Bay species; (2) no feasible alternatives to the fill exist to achieve the project purpose with fewer adverse impacts to Bay resources; (3) the amount of dredged material to be used is the minimum amount necessary to achieve the purpose of the project; (4) beneficial uses of the Bay and Bay water quality will be protected; and (5) there is a high certainty that the project will be successful and not result in significant environmental harm.

(b) The project includes an adequate monitoring and management plan and has been carefully planned, and the Commission has established measurable performance objectives and controls that will ensure the success and permanence of the project.

(c) The project is either a small pilot project or the success of similar projects has been demonstrated in similar environmental settings.

(d) The project will use only clean material suitable for aquatic disposal and will not result in a net loss of Bay surface area or volume.

(e) Fill will not be placed in areas with particularly high existing natural resource values, such as eelgrass beds and tidal marsh and mudflats, unless the fill is needed to protect or enhance the habitat. ~~Dredged materials should be used to create artificial islands in the Bay only if competent studies demonstrate that these fill islands would have no harmful effect on Bay natural resources.~~

(f) If, after a reasonable period of monitoring, either (a) the fill project has not met its goals and measurable objectives, and attempts at remediation have proven unsuccessful, or (b) the fill is found to have substantial adverse impacts on the natural resources of the Bay, the fill should be removed and the site returned to the conditions existing immediately preceding placement of the fill, unless it is demonstrated by competent environmental studies that removing the fill would have a greater adverse effect on the Bay than allowing it to remain.

2.0 PLANNING AREA

The Planning Area for the purposes of this environmental analysis is the water area within BCDC's jurisdiction, which is shown within the dashed line on Figure 1. (Figures are located at the end of this document.)

3.0 POTENTIAL ENHANCED/CREATED HABITATS

The proposed action — the proposed amendment — would clarify the policies that the BCDC should use to consider applications for reuse of dredged material in Bay habitat projects, as distinct from dredged material disposal at the existing in-Bay disposal sites. This would include, among other possible actions, placing dredged material at target sites to create the substrate, elevations, and slopes to support development of a habitat of greater ecological value than the existing habitat at the site. This section describes the type of habitats that could be enhanced or created in San Francisco Bay as a means of beneficially reusing dredged material. All of these habitats occur in the Bay at present.

3.1 GENERAL CONSTRUCTION METHODS

To create these habitats, dredged material would be placed by a variety of methods, including but not limited to discharge from a split-hull barge or scow or discharge in a slurry through a pipeline as part of a hydraulic dredging and pumping method (this latter requires the placement site to be located close to the dredging site). Both the barge/scow and pipeline can be operated to achieve the desired elevations and slopes with reasonable accuracy. For higher elevation habitats (salt marsh), the dredged material can be placed in a variety of ways, including clamshell, placement from barge, or discharge of a slurry from a pipeline. Methods are available to reduce the turbidity created by this placement, such as deploying silt curtains or constructing submerged berms to contain the placed material, as well as other methods. The appropriate method for controlling turbidity would be addressed in project-specific environmental reviews.

3.2 DESCRIPTION OF HABITAT TYPES

3.2.1 Eelgrass

Eelgrass (*Zostera marina*) beds are a valuable type of shallow-water habitat that has limited occurrence in San Francisco Bay. Eelgrass beds are productive habitats that provide refuge and valuable nursery habitat for many fish and invertebrate species. In addition, these beds provide spawning habitat for species such as the Pacific herring (*Clupea pallassi*), and serve as foraging habitat for birds such as the California least tern (*Sterna antillarum browni*) and other species. Eelgrass beds generally occur in shallow (0 to –6 feet mean lower low water [MLLW]) subtidal areas with mixed sand and silt substrate. Key factors influencing the establishment and persistence of eelgrass include substrate, available light, salinity, and temperature, which are in turn affected by depth, wave energy, water circulation, and turbidity. For example, in turbid water bodies such as San Francisco Bay, the depth to which eelgrass can grow is often limited by light availability.

Eelgrass is a flowering grass-like plant with both perennial and annual populations. Perennial eelgrass plants propagate primarily through vegetative growth, extending rhizomes (lateral roots) through the substrate to form new shoots. This helps to stabilize and bind sediments. Annuals propagate primarily through seed dispersal at the end of the growing season and germinate the following spring to reestablish the bed.

Eelgrass beds have been afforded special management considerations by the California Department of Fish and Game (CDFG), U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and non-government organizations such as the Golden Gate Audubon

Society. They have also been the subject of several transplanting efforts in the San Francisco Bay area (Merkel & Associates 1998, Thayer et al. 1984). These efforts have met with mixed success. It has been proposed that eelgrass transplanting can be successful in San Francisco Bay if the transplant site is carefully chosen and/or modified to have suitable environmental conditions (Merkel & Associates 1998). Under the proposed Bay Plan Amendment, eelgrass habitat could be created by placing dredged material that represents suitable substrate (see section 3.3) at suitable elevations (0 to –6 feet MLLW) at the target site. The surface of the substrate would be level or very gently sloping. The site should have low to moderate turbidity, limited wave energy to maintain suitable substrate, and good circulation and flushing to ensure adequate water quality (temperature, dissolved oxygen, etc.). Eelgrass plants would be established through a combination of transplanting and natural colonization. Plants initially established by transplanting would serve as source beds for natural seedling and vegetative expansion.

3.2.2 Unvegetated Shallow Subtidal

This habitat type would consist of gently sloping areas with coarse to fine sediment substrate at elevations above –20 feet MLLW (most projects would probably target elevations above –10 feet because this habitat is generally more productive and valuable than deeper habitat). A substrate of mixed sand and silt would be preferable in terms of the community and functions that would develop at the site. Through colonization, this habitat would be expected to develop a diverse infaunal community, as described in section 4.2.1. It would also provide habitat (including foraging habitat) for fish favoring shallow water (section 4.2.1), and habitat for epibenthic invertebrates such as crabs, shrimp, snails and echinoderms. This shallow habitat would provide refugia and nursery habitat for small and juvenile fish and invertebrates, albeit without the physical structure provided by vegetation. Potential foraging habitat for birds such as the California least tern would also be provided. If elevation, substrate, and other factors are suitable, it is possible that the area could be colonized by eelgrass.

3.2.3 Intertidal Mud/Sand Flats

This habitat type would consist of very gently sloping areas with fine to sandy sediment substrate at elevations between MLLW and mean higher high water (MHHW — approximately +6 feet MLLW in San Francisco Bay). The habitat would develop a diverse and productive infaunal and epifaunal community typical of San Francisco Bay mud/sand flats. The density and diversity of organisms is often higher in mudflats than in sand flats, in part because mudflats tend to be more physically stable than sand flats. Common invertebrates would include clams such as *Macoma balthica* and *Mya arenaria* (the soft-shelled clam), the snail *Ilyanassa obsoleta*, several species of polychaete, and small crustaceans. At high tide, these areas provide valuable feeding and refuge habitat for small and juvenile fish, and foraging habitat for larger fish. At low tide, these areas are productive feeding habitat for shorebirds. If elevation, substrate, and other factors are favorable, these areas can be colonized by salt marsh plant species (see next section). Red and green algae also occur in mudflats.

3.2.4 Salt Marsh

This habitat type would consist of gently sloping areas with medium to fine sediments at elevations in the upper part of the intertidal range, approximately +3 feet to +8 feet MLLW. Most of San Francisco Bay's salt marshes have been lost through diking, filling, and other shoreline development. Salt marshes typically consist of broad vegetated areas incised by tidal channels. The most prevalent plant in San Francisco Bay salt marshes is pickleweed, *Salicornia virginica.* Other common plant species are saltgrass (*Distichlis spicata*); *Jaumea carnosa*, a creeping perennial of the aster family; and, especially in lower elevations, cord grass (*Spartina foliosa*). In San Francisco Bay, the introduced *Spartina alterniflora* and *S. Foliosa/alterniflora* hybrids are also common. Large and microscopic algae also occur in salt marshes. Common invertebrates include the amphipod *Traskorchestia traskiana*, several species of snail, and the crab *Hemigrapsus oregonensis.* San Francisco Bay salt marshes provide important habitat for the California clapper rail, an endangered species, and the California black rail, a threatened species; and essentially the only habitat for the endangered salt marsh harvest mouse. Existing habitat for these species in San Francisco Bay is very limited, and increasing habitat for these rare species is a main impetus for creating/restoring salt marsh habitat. Salt marshes also provide feeding and nursery habitat for fish, and foraging habitat for shorebirds and waterbirds.

3.2.5 Islands for Bird Use

This habitat type consists of small islands constructed in shallow-water areas to provide isolated habitat for bird roosting and nesting. The purpose of this habitat type is to provide bird roosting and nesting areas that are somewhat protected (by water) from mammalian predators and human interference. These islands would have a maximum elevation of +8 feet to +12 feet MLLW. They can be constructed of dredged material capped with hard substrate with few voids to minimize erosion and refuges for mammalian predators. Such islands can be constructed in existing shallow water or as part of a larger shallow-water enhancement project. Birds potentially benefiting from such islands include the California least tern, herons, egrets, shorebirds, and waterfowl.

3.3 SEDIMENT TYPES SUITABLE FOR HABITAT ENHANCEMENT

This section describes the general characteristics of sediments that would be suitable for shallow-water habitat enhancement in San Francisco Bay. It is assumed that sediments identified for habitat enhancement would be relatively free of contaminants and deemed suitable for unconfined open-water disposal/reuse. Sediments suitable for beneficial reuse are often identified through maintenance dredging projects within San Francisco Bay and can consist of a wide range of sediment types, including highly organic fine-grained material (silts and clays) to coarse sands and/or gravels with relatively low organic content.

Five habitats, both vegetated (e.g., eelgrass) and unvegetated, are identified as potential beneficial reuse habitats using dredged material in San Francisco Bay: eelgrass, unvegetated shallow subtidal, intertidal mud/sand flats, salt marsh, and islands for bird use (section 3.2). The general sediment character suitable for each habitat type is described below. Provided that the beneficial reuse sediments are suitable for open water disposal/reuse, there is some flexibility in the way sediments are used for habitat enhancement. For example, a fine grained sediment mixture (e.g., sandy silt) may not be an ideal substrate for eelgrass habitat, but it could be considered suitable material, provided other environmental parameters are met. Surface sediments used for habitat enhancement should be selected so that they will be stable and remain in place, as designed. However, the potential exists for physical failure, where sediments do not remain in place, or physical features such as elevation and slope are not maintained. Each potential site is unique and a site-specific assessment and design determines the likelihood of success for habitat enhancement.

3.3.1 Eelgrass

In San Francisco Bay, the predominant seagrass in shallow-water habitats is eelgrass (*Zostera marina* L.). Small amounts of two other seagrasses, surfgrass (*Phyllospadix torreyi* and *P. scouleri* in more surfswept rocky areas) and widgeon grass (*Ruppia maritima* in brackish or freshwater areas) are present (Kitting and Wyllie-Echeverria 1992). Multiple environmental factors interact to control the distribution of eelgrass, including substrate type (sediment type), stability, light, salinity, and hydrodynamics (wave action). In particular, light is a limiting condition in San Francisco Bay due to the large amounts of particulate matter carried by Bay waters (Wyllie-Echeverria and Rutten 1989).

Sediments generally suitable for eelgrass habitat are coarse to very fine sands (0.1 mm to 1.0 mm) with relatively low total organic content (TOC) (personal communication, K. Merkel 2000). High TOC content could lead to anaerobic sediment conditions. Although eelgrass has a wide tolerance for sediment characteristics, transplants appear to be most successful on the recommended substrate type. The sediment texture and composition affects the ability of eelgrass to establish roots and obtain nutrients and dissolved oxygen. Sediment nutrient levels (inorganic nitrogen and phosphate) are not considered limiting, although excess nutrients can impact eelgrass productivity by accelerating ephiphyte (algae) growth. Salinity is not a limiting parameter for sediments proposed for habitat enhancement, because the sediment will equilibrate in a relatively short time (personal communication, K. Merkel 2000). Site stability is an important factor in the eelgrass community structure. When sediments are placed at a site for eelgrass habitat, a minimum of 2 weeks should be allowed for settling (Merkel 1992). The sediments should then be assessed for site stability. For spring season eelgrass transplant projects with no anticipation of winter storms, erosion rates of 0.5 mm/day are generally acceptable with sedimentation rates no more than 0.3 mm/day (Merkel 1992).

In areas of San Francisco Bay where bottom current velocities are low, fine sediments typically contain high organic content and are not suitable habitat for eelgrass. Conversely, very coarse and unstable sediments do not provide suitable habitat for eelgrass (USACE 1996). Once established, eelgrass stabilizes the sediments in two ways:

(1) The leaves slow and retard current flow, reducing water velocity near the sediment-water interface, which promotes sedimentation of particles and inhibits resuspension of organic and inorganic material and,

(2) Rhizomes and roots form an interlocking matrix, which bonds sediment and retards erosion (Wyllie Echeverria 1988).

In some instances, enhancement projects for eelgrass habitat may require the use of rock or other hard materials for containing dredged material (e.g., submerged dike, breakwater). As an added benefit, these hard surfaces can provide substrate for algae, attached invertebrates (e.g., mussels, sponges, tunicates), and habitat for fish and mobile invertebrates (e.g., crustaceans). In deep-water areas, hard substrate may be suitable for kelp.

3.3.2 Unvegetated Shallow Subtidal

Unvegetated shallow subtidal habitat can include subtidal mud or sand flats, slopes, or a mixture of sands and silt. This habitat type can accommodate a range of different sediment types, but the suitability of the material depends on the hydrodynamics of the proposed site. For example, shallow subtidal habitat (shallower than –20 feet MLLW) in a low to moderate energy area can accommodate silts (0.005 mm to 0.05 mm) to fine to coarse sands (0.05 mm to 2.0 mm) for habitat enhancement. Sediments for this habitat should contain low to moderate levels of TOC. Extremely anaerobic sediments should be avoided for surface material at a habitat enhancement site. Exposure of this material to aerobic conditions could lead to sediment toxicity (conversion of hydrogen sulfide in sediments to acidic by-products).

Given the proper conventional parameters (light, elevation, and circulation), shallow subtidal habitat could be suitable for eelgrass as well. The particle size and compaction parameters of the sediment will determine the types of infaunal organisms that burrow into the substrate. The hydrodynamics will also determine what sediment grain size will remain in place (Figure 2), and the optimum profile and gradient (average slope between seaward and landward limits) of each habitat enhancement site.

3.3.3 Intertidal Mud/Sand Flats

Sediments suitable for intertidal mud/sand flats can be similar in character to sediments suitable for unvegetated shallow subtidal habitat. Shallow mud flats and sand flats are characterized by broad, flat expanses of silt and clay (less than 0.05 mm) or very fine to fine sand (0.05 to 0.2 mm) in shallow intertidal areas (typically 0 to about +6 feet MLLW). This habitat is found in protected and unprotected parts of San Francisco Bay, although areas sheltered from the effects of wind-driven waves may provide more favorable conditions for habitat enhancement (e.g., in the shelter of spits, within estuary channels).

3.3.4 Salt Marsh

Typical sediments for this habitat consist of silts and clays (grain size less than 0.05 mm) with high organic content. However, fine-grained sediments that are low in organic content could be used in a beneficial reuse project, provided the sediments are amended to increase organic content (personal communication, K. Merkel 2000) or if sufficient natural sedimentation is expected on the placed sediments. Plant species in salt marshes are tolerant of low dissolved oxygen and limited tidal flushing. Therefore, fine-grained sediments with high TOC are suitable to the vegetation found in this habitat type. Salt marshes are vegetated mudflats that are generally at a higher elevation, relative to mean tide level, than mudflats. The upper marsh area is exposed for a long enough period each day to allow vegetation growth (approximately +3 to +8 feet MLLW). This habitat is found in many protected and less protected parts of the Bay, although well-protected areas may provide more favorable conditions for habitat enhancement (e.g., deep within an enclosed embayment).

3.3.5 Islands for Bird Use

Islands for bird nesting and/or roosting can be created using dredged material. In some cases, it may be advantageous to cover the dredged material with rocks or other hard material. Coarser dredged material is preferable for islands because it is less likely than fine material to be transported by currents and waves. Island areas can provide greater physical separation and a water barrier between bird nesting and roosting areas and shoreline access areas. This separation reduces the potential threat of predation by mammals, and potential disturbance by humans.

An important design consideration for island construction is the amount of settling anticipated from the build-up of dredged and/or rocky material. The bird islands should be constructed so that birds would find the site to be a desirable area for nesting and/or roosting. For example, the bird islands proposed for the Oakland Harbor Middle Harbor Enhancement Area (MHEA) site are proposed to be capped with quarry stone filled with bedding gravel in all void spaces (Merkel & Associates 2000). This will preclude vegetation growth, protect the islands from erosion, and eliminate potential predator refuges associated with earthen and rip-rap surfaces.

3.4 LESSONS LEARNED FROM HABITAT ENHANCEMENT PROJECTS

Projects using dredged material to create, enhance, or restore aquatic habitat have been implemented at many sites across the United States. Many of these projects have been successful; others have met with partial or full failure. In order to maximize the environmental benefits of future habitat projects in San Francisco Bay, it is important to understand the factors that influenced the success, or lack of success, of past projects. This section presents the results of reviews of lessons learned from national program and research synthesis reports concerning habitat development using dredged material. Aquatic and wetland habitats are emphasized. The broad lessons learned from habitat development projects throughout the United States are supplemented with experiences from specific projects outside and within the San Francisco Bay Region.

3.4.1 CONCLUSIONS FROM NATIONAL REVIEWS AND SYNTHESIS DOCUMENTS

The information contained in this section is derived from three sources: two of the sources are syntheses of results of research and demonstrations concerning habitat development conducted by the U.S. Army Corps of Engineers' Dredged Material Research Program; the third source is a national review of non-Corps environmental restoration projects, which was also funded by the Corps of Engineers.

Wetland Habitat Development with Dredged Material: Engineering and Plant Propagation (Environmental Laboratory 1978)

It is important to recognize the unique characteristics of every potential habitat development site by considering the following **site selection** factors:

a) Availability of the site for disposal or development that considers ownership, disposal agreements, land use classification, and scheduling requirements;

b) Capacity of the site to contain the dredged material volume;

c) Proximity to the dredging project as it affects the cost to transport material to the habitat development site;

d) Physical and engineering features including the ability of the site's foundation to support dikes, or the potential for physical energy from currents and waves to erode the dredged material substrate or planted vegetation; and

e) Environmental and social acceptability that includes effects on adjacent habitats, alterations in water quality or flow, and the public's perception of the project.

The goal is to define a feasible site. Such a site is defined by considering the above factors, the severity of the engineering or biological or social problems encountered, and the level of effort that will be required to manage or mitigate those problems. A point may be reached when the development of a site becomes too time consuming, or too expensive, and is dropped from further consideration.

A thorough **site characterization** is important to define substrate and water physical and chemical characteristics, including elevation or water depth; the characteristics of the plant and animal communities; and the characteristics of areas in the vicinity of the site where the biological communities targeted by the project are successful. This speaks to the importance of the appropriate intertidal elevations for wetland plants or water depths for submerged aquatic vegetation.

Goal definition usually involves obvious project outcomes such as the success of the plant establishment program. But less direct goals are often more important. For example, improvements to water quality or provisions for fish or wildlife habitat may be the ultimate goals. These indirect goals must be included in the project planning.

Potential problems must be identified as early as possible. Most often these problems are the result of inadequate attention to permitting and ownership issues, inadequate public involvement and consequent public resistance, or underestimates of project costs.

Upland and Wetland Habitat Development with Dredged Material: Ecological Considerations (Lunz et al. 1978)

When habitat development is dissected into basic parts, it has been shown to be simply an extension of ecological principles. That is why emphasis must be placed on sound planning and the clear definition of objectives that will avoid ecological conflicts. The management potential of habitat development is best considered in an ecosystem context. The developed habitats should not only visually fit into the system, but must provide functional support as well. To this end an understanding of animal-habitat interactions is essential.

Pollutant mobilization, uptake, and food chain contamination are concerns that rely on understanding the characteristics of the dredged material to be used in the project, and of the physical-chemical conditions that affect chemical solubility and mobility, and availability to plant and animal populations.

National Review of Non-Corps Restoration Projects (Shreffler et al. 1995)

A restoration project can usually be divided into four primary phases:

- The **planning and design** includes establishing goals and objectives. An example of a goal statement is given as, “The goal of the project is to reestablish tidal marsh communities to Site A. This may be accomplished through reestablishing natural tidal hydrology and removing other major impediments to marsh development.”

  Establishing a model system, preferably very near the system to be restored, will assist in understanding what types of actions are needed to restore the system and what the system is expected to look like after a period of development following physical changes.

  Performance criteria should be established that consider time scales, spatial scales, habitat structure and function, the potential for the habitat to be self-sustaining, and the resilience of the system to disturbance by man or nature.

- The **construction phase** consists of any pre-assessment (e.g., level of dredged material or site sediment contamination) required prior to construction, as well as the actual construction of the project. Someone who is intimately aware of the goals of the project must monitor construction. In some instances elevations of only a few centimeters may significantly impact hydrology and the successful establishment of vegetation.

- An **assessment and adjustment phase** involving monitoring is used to measure progress toward the goals using the performance criteria. If conditions are not developing as planned, adjustments can and should be made. This phase is often referred to as the **adaptive management phase.** It acknowledges that natural processes will ultimately dictate the development of the system, and that any physical alterations required to assure that the system meets the goals for the project should be carried out with the understanding of how nature is altering the system.

- In the **documentation and communication phase** all aspects of the project should be documented. Accurate and consistent record keeping is useful for documenting the effects of decisions and for showing progress toward goals. It is essential to communicate how well the system performed relative to the goal of the project, and to use data acquired through monitoring, and with reference to the performance criteria.

3.4.2 CONCLUSIONS FROM SPECIFIC PROJECTS

In this section the conditions affecting project success have been divided into four types of factors. These factors are: (1) physical-chemical, (2) biological, (3) engineering and economic, and (4) social. Following a description of each factor below, the factor is briefly discussed using examples from specific aquatic and wetland habitat development projects.

3.4.2.1 Aquatic Projects

The information about specific projects discussed in this section is largely derived from Merkel and Associates (1998b).

Physical and chemical project factors include the following:

- Elevation or depth and, related to depth, the amount of light reaching the bottom when the substrate is flooded;

- The physical energy caused by currents and waves which, in turn, are affected by prevailing winds and storms;

- Substrate, which is usually classified by the grain size of the particles, and typically divided into cobble, gravel, sand, silt or clay, or some combination of the particle sizes;

- Substrate gradient or slope; and

- Substrate chemistry including contaminants and nutrients.

These conditions are vitally important to project success. For example, the achievement of the goal of the Permanent Shallow Water Habitat Project in Los Angeles Harbor depended upon achieving a final substrate depth and sandy (light colored) bottom to support least tern foraging on fish living in the shallow protected site. The Port of Long Beach Shallow Water Mitigation Site required similar conditions even though the two sites had very different characteristics at the inception of the projects. In the Richmond Harbor Training Jetty eelgrass project, the depth and consequently the light conditions in a naturally turbid environment impacted the survival of the transplanted eelgrass. The plantings may have been more successful if dredged material or other suitable sediments had been used to reduce the depth in the transplant area. The complex habitat restoration of Batiquitos Lagoon (Carlsbad, California) required careful attention to depth and elevation for non-vegetated and vegetated (eelgrass) habitats and intertidal wetland plantings. Regarding elevation control and its importance in the development of wetland habitats using dredged material, it is important to account for changes in elevation that may occur due to the consolidation of dredged material that has been placed intertidally. Under circumstances where consolidation-related changes in elevation are anticipated, plant propagation activities should be delayed or adjusted to account for future changes in the elevation of the substrate.

Biological factors include:

- Plant species selection and the suitability of the source of plants to the project site;
- Plant propagation methods and conditions;
- Animal-habitat interactions; and
- Impacts due to grazing by non-target animals such as geese, nutria, cattle and goats, or other damage to the engineered habitat caused by tunneling by muskrat or beaver.

The goal of the Port of Los Angeles and Port of Long Beach Shallow Water Habitat Projects was established based upon the assumption that if an aquatic habitat with the right physical features is created, the animals will populate the habitat and the habitat will develop functional value. Another way of saying this is that the achievement of the goals of these projects depended on predicted animal-habitat interactions. The Pier 300 Project at the Port of LA was successful because its predicted goal was achieved when the endangered California least tern began foraging for fish at the site, which was created for that specific reason. Data was not available at the time this document was written with which to determine the biological success of the Port of Long Beach project, but the physical goals of the project were achieved. It is reasonable to expect shallow-water aquatic community conditions to develop in and on the substrate of the site.

Both the season selected for transplanting, and the source of eelgrass transplant materials appear to have been factors that reduced the success of the eelgrass transplants at the Richmond Harbor Training Jetty Project. The plants flowered shortly after being transplanted, which suggests the transplanting may have shocked them. The flowering also reduced the energy available to the plants for increasing their density. It is also possible that the area used as the eelgrass donor site contained plants that were not tolerant of the turbid, low-light conditions at the transplant site. Merkel and Associates (1998b) describes experimental eelgrass transplants conducted by Wyllie-Echeverria and Phillips (unpublished data) in which plants were moved from Point Molate (near Richmond, California) to Keil Cove, San Francisco Bay and reciprocally transplanted. Plants from the more turbid Point Molate site were able to colonize Keil Cove, however Keil Cove plants could not withstand the conditions of Point Molate. According to Merkel and Associates (1998b), Wyllie-Echeverria and Phillips argue that this is an indication of differences in environmental tolerances between populations within San Francisco Bay.

In Batiquitos Lagoon, there are many biological indicators of project success in responses by invertebrates, fishes, and birds. This complex restoration project was designed to reestablish substrate and vegetated habitat conditions that would support these animal communities. This project involved dredging, creation of shallow-water basins, tern colonies, and pilot-scale restoration of eelgrass and cordgrass habitats. Benthic infaunal invertebrate diversity and abundance increased. The number of recorded fish species increased from 8 to 52 between pre- and post-restoration conditions. Least tern numbers increased by 800% and snowy plover numbers increased by 700% compared to pre-restoration conditions.

Engineering and economic factors include:

- Elevation control;
- Erosion protection for both substrate and planted vegetation;
- Hydrologic control;
- Foundation strength and stability; and
- Construction and adaptive management costs.

Foundation conditions were an important determinant of the success of the Port of LA's Permanent Shallow Water Habitat because the project proceeded in stages, which required the construction of underwater dikes to contain material dredged from the LA Harbor floor. The stability and the persistence of the dikes required foundation information that was used to design the dikes and their construction.

The Batiquitos Lagoon Project included the restoration of hydrologic conditions as a primary engineering objective. The restoration of flows was critical to the successful development of conditions for the shallow-water unvegetated and vegetated substrates and vegetated wetland substrates constructed as a part of this project. The problem was that the Lagoon's outlet to the ocean had become blocked by shore processes. The blockage was removed by dredging.

Social factors include reactions to the proposed project from the public, non-project institutions, and government agencies. These reactions can be very negative and very important determinants of project feasibility. The projects that were reviewed in this section were not impacted by adverse social reactions, but other habitat development projects have been. Examples of social conditions affecting projects are:

- A "Not in my back yard" attitude that attends the perception that a project is experimental, or the view that there is a risk of failure that may lead to a visual, olfactory, or even to a public health nuisance;
- Objections to the project that are motivated by unfounded fears, which are often caused by an ineffective public outreach program; and
- Concerns over the effect of a project on property values and water views that may be the result of the construction of a wetland or island habitat.

3.4.2.2 Wetland Projects

Conclusions were drawn based on specific factors that influenced success or failure of a number of past projects. Success or lack of success was often attributed to the presence or absence of extensive planning. Other key factors have been broken into the four categories described above: Physical/Chemical Factors, Biological Factors, Social Factors, and Engineering and Economic Factors.

Physical/Chemical Factors

The most widely acknowledged factors in determining success or failure of a project were final elevation and slope (grading). These factors are important to achieving desired biological productivity of the established habitat, as evidenced by the Concord Naval Weapons Station Tidal Marsh Restoration in San Francisco. In this project, achieving proper elevation and grading allowed adequate water inundation without stagnation (personal communication, Santana and Gleason 2000). Density and diversity of plants have been shown to generally decline with increased inundation, so the magnitude, duration, and frequency of tidal inundation must be considered. Selection and establishment of plantings will depend upon these factors. In addition, water depth and quality, and substrate type should be considered when selecting vegetation (USACE 1996, Clairain et al. 1978).

When selecting substrate size, much attention should be given to energy regime (wave, current, wind) and desired habitat type. The sediment characteristics will affect the type of benthos and subsequent predators that use the site. Fertilization may or may not be needed, depending upon the substrate employed. Overall nutrient budgeting within the estuary should be considered (availability of nutrients to plants based on organic content and pH).

Seasonality is an important factor affecting many aspects of projects. Rains during the fall and winter at Concord Naval Weapons Station (NWS) often made working in wetland areas prohibitive (personal communication, Lee 2000). Also, rapid leaching due to heavy rains or substrate size may influence plant response to fertilizer (Merkel & Associates 1998b).

Biological Factors

Seasonal variations occur with respect to turbidity levels and abundance, biomass, and number of species, and should be considered when reviewing monitoring data (Merkel & Associates 1998b). Seasonality can also have a great effect on the time and location of plantings as well as their overall survival (Allen et al. 1978).

Selecting the proper vegetation for the site has the important benefit of substrate stabilization. Plants with spreading, fibrous, and shallow root systems are well suited for stabilizing sediments and helping to resist resuspension and erosion of the dredged material (Cole 1978). Some degree of succession will occur on the site; however, weeding should be considered if the overall value of the target vegetation is greater than that of invading vegetation (Lunz et al. 1978).

Loss of vegetation due to competition and grazing should be major considerations (including grazers such as Canada geese, nutria, and domestic and farm animals) (Lunz et al. 1978). At the Bolivar Peninsula Marsh and Upland Habitat Development Site in Galveston Bay, Texas, use of fences contributed to the nesting success of the California least tern (Allen et al. 1978). However, it also had the effect of preventing some pre-project species from returning to the site.

Salt marsh vegetation often colonizes on its own, but this can be facilitated through use of cores, transplants and seeding, as seen at Concord NWS where heavy and extensive planting contributed to rapid and successful re-propagation of target vegetation (pickleweed *Salicornia* sp.) (personal communication, Lee and Gleason 2000). Seeding was often just as effective as sprigging or transplanting in other projects. Consideration must always be made to the cost and potential for tidal washout, however. In addition, plant invasion tends to be more rapid in areas protected from wave action (Lunz et al. 1978).

A suitable habitat may not always vegetate on its own. Buttermilk Sound Salt Marsh, located on the Altamaha River in Georgia, was planted several years after the original deposition of dredged material for habitat enhancement, since it had not revegetated on its own. The site was successfully revegetated and, since 1979, has been similar to nearby natural marshes in species composition and density (USACE 1987).

Engineering and Economic Factors

Planning, including engineering, was cited as an important factor for many projects. At Concord NWS, planning was extensive and more than anticipated, but the success of the project was largely credited to this planning (personal communication, Gleason 2000). Baseline data are crucial for documenting changes associated with site development and should be considered in the planning stage. Another factor to anticipate in the planning stage is maintenance action in order to address material consolidation, accumulation and erosion (Merkel & Associates 1998b). Pilot studies often permit more effective planning of site specific engineering and of future monitoring. An example is the Sonoma Baylands wetland restoration project in northern San Francisco Bay, where a 39-acre pilot project provided lessons learned for the full 348-acre project entailing dike breaching and dredged material placement to achieve proper elevations for establishment of a wetland community (Coastal America 1996).

Based on the energy regime of the site, dikes may be needed. Solids retention is usually successful with a dike, and often is not successful without a dike. This is the case at Windmill Point Marsh Development Site located on the James River in Virginia, where the dike was determined to be essential to the physical stability of the site. Consideration also needs to be paid as to whether the site can support the methods employed. Some dike methods may be rejected due to weak foundation soils, which are not likely to support the concentrated loads produced by those diking methods (Allen et al. 1978, Lunz et al. 1978).

As mentioned above, the Concord NWS project demonstrated the importance of elevation and slope (grading) to achieving desired biological benefits. This was considered the most difficult portion of the project, and, through a combination of engineering and construction methods, proper elevation and grading were achieved (personal communication, Santana and Gleason 2000).

Economic factors also include the project's compatibility with the time frame and the site's proximity to the dredged material to be used.

Social Factors

These can be the greatest hindrance to a project's success if not addressed in the planning stage. For example, the Tampa Bay Habitat Mitigation Improvement Project in Tampa Bay, Florida, was a biological success, as well as a public relations success in part due to the involvement and input from 17 community organizations (USACE 1996).

3.4.3 Summary

The lessons learned from past habitat projects can be summarized as follows.

- Proper planning is critical to project success. This should include establishment of clear project goals, a good understanding of the physical conditions required by the target biological community, selection of the target site based on thorough characterization of the physical and biological conditions of the site, careful project design, and a realistic assessment of the likelihood of project success.

- A good understanding of pre-project and post-project hydrological conditions is important to the physical stability of the site, biological success, and water quality impacts.

- Proper elevation and grading are important to the success of habitat projects. This includes consideration of the effects of consolidation of dredged material after placement.

- The schedule for habitat construction should consider impacts from seasonal effects (e.g., heavy rains during fall and winter) and potential impacts to wildlife, especially endangered species (e.g., salmon migration).

- Transplanting and/or seeding the site often results in faster revegetation than would occur through natural colonization. The source of plant materials should be selected to be compatible with conditions at the target site.

- Performance criteria defining project success should be established and evaluated through a long-term monitoring program. Adaptive management of the project site should be used to maximize the ecological benefits of the project.

- Pilot projects can be useful in guiding full-scale projects.

- An effective public outreach program should be used to facilitate public acceptance of the project, which will affect the perception of project success.

4.0 EXISTING HABITAT TYPES IN SAN FRANCISCO BAY

4.1 DESCRIPTION OF EXISTING HABITAT TYPES

For the purposes of describing environmental conditions in San Francisco Bay, the Bay was divided up into the six major habitat types listed below, based largely on water depth and substrate type. The percent of the study area that habitat types 1 through 4 below occupy is noted also. Habitat type 5 — dredged areas — overlaps with some of the four preceding habitat types, so the percent of the Bay area that it occupies is not noted below.

1. Deep water (greater than 20 feet MLLW), rocky bottom — 2% of the Bay,
2. Deep water, coarse-grained sediment (sand) — 8% of the Bay,
3. Deep water, fine-grained sediment (mud) — 17% of the Bay,
4. Shallow water (less than 20 feet MLLW) — 73% of the Bay,
5. Dredged areas (navigation channels and berths), and
6. Tidal Marsh.

The locations of these six habitat types are shown for San Francisco Bay overall in Figure 3. The same information is shown for smaller areas of the Bay at a larger scale in Figure 4 (South Bay), Figure 5 (Central Bay), Figure 6 (San Pablo Bay), and Figure 7 (northeastern San Francisco Bay).

Figures 3 through 7 were developed to delineate generalized bottom types of deep water (greater than 20 feet below MLLW) and shallow water (less than 20 feet below MLLW) in the San Francisco Bay area. Generalized bottom types include coarse-grained sediments, fine-grained sediments, and rocky areas. Federal shipping channels have also been delineated on these maps. Channels dredged by local jurisdictions are not included on this map.

The marine sediment types shown on Figures 3 through 7 were primarily derived from California Division of Mines and Geology (CDMG) Special Report 97 (CDMG 1969). These data were supplemented by maps created by Jones and Stokes (1979), on which additional rocky areas were defined. Bathymetry data of San Francisco Bay and San Pablo Bay were derived from a U.S. Geological Survey (USGS) Digital Elevation Model. Bathymetry data of Suisun Bay, Honker Bay, and Grizzly Bay were derived from digitizing hard-copy USGS 1:24,000-scale quadrangles for Benicia, Vine Hill, Antioch North, and Honker Bay. Official National Oceanic and Atmospheric Administration (NOAA) digital navigation charts were utilized for delineation of federal channels. These channel data were generally confirmed through consultation with the Army Corps of Engineers — San Francisco District office (personal communication, K. Mason 2000).

The six habitat types listed above differ in their environmental conditions and in the feasibility and benefits of creating the various habitat types described in Chapter 3. The feasibility and suitability of creating these habitat types in each of these six existing habitat types are addressed in Chapter 5, while the environmental benefits of creating these habitats are addressed as part of the impact assessment in Chapter 6.

Shallow-water habitat is generally more productive and valuable than deep-water habitat. Compared to deep-water habitat, shallow-water habitat has better light availability, better conditions for growth of aquatic vegetation, greater productivity by vegetation and planktonic producers, and greater diversity and abundance of benthic organisms and fish. As a result, one of the most important values of shallow-water habitat is as nursery and rearing habitat for fish and invertebrates, providing food, refuge and other functions. These areas also provide important foraging habitat for larger fish, birds, and other wildlife. A water depth of 20 feet below MLLW is a commonly used approximation of the boundary between deep-water habitat and shallow-water habitat in marine and estuarine systems (USFWS 1998). This is based in part on areas less than approximately 20 feet deep generally exhibiting the advantages of shallow habitat listed above. It also considers the concept of photo-compensation depth, which is the depth at which light availability is sufficient to support primary productivity in excess of respiration, allowing vegetation to grow. This has a fundamental effect on the productivity potential of the habitat. In turbid water bodies such as San Francisco Bay, the photo-compensation depth, and the depth at which the other advantages of shallow habitat prevail, is usually less than 20 feet MLLW. However, in the Bay turbidity and light penetration vary greatly by location, time of year, and weather, making it very difficult to define an “average” boundary between deep and shallow habitat based on ecological function factors. Therefore, the 20-foot. MLLW contour is used for this boundary for mapping purposes in Figures 3 through 7. This should not be interpreted to mean that 20 feet MLLW is appropriate to define shallow habitat throughout the study area on an ecological function basis, however.

Although shallow habitat is generally more productive than deep habitat, deep habitat can still be valuable by providing habitat and species diversity in mostly shallow water bodies such as San Francisco Bay. Some species are adapted to deep habitat (rocky or sediment bottom), while others require deep habitat during at least part of their life cycle.

Figure 3 shows that, outside of the central Bay, areas deeper than 20 feet occur primarily in dredged navigation channels, and other dredged areas such as the Bay Farm Borrow Area west of Bay Farm Island. There are some naturally deep areas in the northern part of the south Bay.

4.1.1 Deep Water, Rocky Bottom

As shown in Figure 3, this habitat type occurs primarily near the mouth of the Bay and in the central Bay, in areas that are naturally deep and have strong water currents (primarily tidal) that scour the bottom and prevent the settlement of sediment, exposing a rocky or other hard substrate. Benthic communities consist primarily of attached invertebrates; fish and mobile invertebrates are also fairly common. Attached vegetation, such as kelp, that can grow in deep water also occurs in these habitats. These areas are poor candidates for beneficial reuse of dredged material, because the strong currents would tend to transport most or all of any dredged material placed there. Also, because of the limited extent of this habitat in the Bay, and its role in providing habitat diversity in a Bay that is otherwise mostly shallow, there is likely to be little benefit in converting this habitat type to another.

4.1.2 Deep Water, Coarse-grained Sediment

This habitat type also occurs primarily in the central Bay, but also extends into the navigation channels in San Pablo Bay and the entrance to Oakland Harbor (dredged areas such as navigation channels are addressed as a separate habitat type in section 4.1.5, below). This habitat occurs in areas where bottom currents are fairly strong, preventing the accumulation of fine sediments. Therefore, these areas would not be suitable for placement of fine sediments for habitat enhancement purposes. These habitats support both demersal (bottom) fish, invertebrate epifauna (animals living on the sediment surface) and invertebrate infauna (animals living within the sediment). Since most of the deep areas in the Bay are fine-grained, the coarse-grained areas provide a degree of habitat diversity. Sediments in these habitats tend to be more physically dynamic and have lower organic content than those in quieter areas where fine sediments predominate. As a result, infaunal communities in coarse-grained habitats often have lower abundance and diversity of organisms than fine sediment communities. Sand mining is common in the Bay, and this is another source of habitat disturbance.

4.1.3 Deep Water, Fine-grained Sediment

This type of habitat is common in the deep areas of the central, north, and especially south Bay (Figures 5, 6, and 4, respectively). This habitat type occurs in areas where bottom currents are fairly weak, allowing fine sediment to accumulate. Like coarse-grained habitats, this habitat supports demersal fish and invertebrate epifaunal and infaunal communities. This habitat is usually more physically stable than coarse-grained habitats, often resulting in more diverse and abundant infaunal communities. Communities in maintained deep areas are disturbed periodically by dredging. In areas of South San Francisco Bay (primarily), shell fragments are mixed in with fine sediments.

4.1.4 Dredged Areas

This habitat type consists of dredged areas, including navigation channels and port berths. In San Francisco Bay, maintained navigation channels are located mostly in the north Bay and south Bay (central Bay is naturally deep). Other dredged areas are berths in Oakland, Richmond, and Redwood City harbors. Substrate in these areas is both fine-grained sediment and coarse-grained sediment (primarily in the north Bay). Biological communities are similar to those described above for coarse-grained and fine-grained habitats. These communities are frequently disturbed by maintenance dredging and ship movement, so they typically are not as fully developed (in terms of density and diversity of organisms) as communities in undredged areas. Use of dredged material for habitat enhancement in active navigation channels and berths is not feasible, because of the interference with navigation. Deepened areas adjacent to closed military facilities and former borrow areas are the most likely dredged areas for habitat enhancement.

4.1.5 Shallow Areas

Shallow areas are defined for the purposes of this analysis to areas with depths less than 20 feet MLLW. Most of San Francisco Bay consists of this habitat type, especially in north Bay and south Bay. Substrate is primarily fine-grained sediment, but there is also considerable coarse-grained sediment, particularly in the north Bay. Biological communities are generally similar to those described above for deep-water coarse-grained and fine-grained habitats, although diversity and productivity is often higher in shallow habitats, and eelgrass or other features are sometimes present. The potential benefits and environmental impacts of converting one type of shallow habitat to another are addressed in Chapters 5 and 6.

4.1.6 Tidal Marsh

This habitat is typified by marsh vegetation growing in gently sloping intertidal areas with fine to medium sediments, incised by tidal channels. In most of the Bay, tidal marsh consists of salt marsh, which is described in section 3.3.4 above. In Suisun Bay and adjacent areas, the mouths of the Petaluma and Napa rivers, and in some parts of South Bay, greater freshwater input results in brackish water and, in tidal areas, brackish marsh, which is characterized by somewhat different species than salt marsh. In the lower intertidal, common brackish marsh plants include cattails (*Typha latifolia*) and California bulrush (*Scirpus californicus*). In the middle intertidal, common plants are California bulrush, spike rush (*Heleocharis* sp.), Baltic rush (*Juncus balticus*), silverweed (*Potentilla anserina*), and saltgrass. High brackish marsh is characterized by pickleweed and saltgrass. Animals of brackish marshes include many of those found in salt marshes (section 3.3.4 and 4.2.1), as well as Delta smelt, longfin smelt, and splittail in the tidal channels of the marsh at high tide.

4.2 EXISTING CONDITIONS

4.2.1 Biological Resources

4.2.1.1 Plankton

The general classes of phytoplankton occurring within the San Francisco Bay estuary include diatoms (Bacillariophyceae), coccolithophores (Haptophyta), dinoflagellates (Pyrrophyta), silicoflagellates (Chrysophyta), cryptomonads (Cryptophyceae), and green algae (Chlorophyceae). Phytoplankton and zooplankton populations within San Francisco Bay generally reflect seasonal variations in physical and chemical parameters such as light, temperature, salinity, available nutrients, upwelling, current regimes, and hydraulic conditions within the estuary (EPA 1993; USACE 1981; Cloern 1979). These factors influence which species are dominant in different areas of San Francisco Bay. For example within the Central Bay, prevalent phytoplankton blooms are comprised of a number of coastal species that have been dispersed into the Bay, particularly during the spring and summer when coastal upwelling is occurring (Conomos 1979). Among these coastal phytoplankton are the diatoms, *Chaetoceros* spp. and *Rhizolenia* spp. (Ball and Arthur 1979; Cloern 1979). Within the South Bay, predominant spring bloom species include the diatoms *Cyclotella* sp., *Thalassiosira* sp., and *Skeletonema costatum* (Cloern 1979).

To the extent that the physical and chemical parameters influencing phytoplankton community composition are related to water depth (e.g. light availability), the species composition, abundance, and biomass may vary among deep and shallow-water habitats. Within San Pablo and Suisun bays, most of the phytoplankton production occurs in the shoals between the deeper channels and shoreline where there is more light available for photosynthesis (SFEP 2000). Phytoplankton may occur in the deeper channels in the vicinity of the entrapment zone, where circulation patterns tend to transport the phytoplankton from shallower areas and concentrate the plankton in the entrapment zone. The diatom *Skeletonema costatum* is prevalent at the north end of the Bay, particularly near shallow tidal flats in the vicinity of the Sacramento-San Joaquin river channel (Cloern 1979). Phytoplankton would also occur in the upper water column in the deep-water habitats under consideration, including the navigation channels.

Zooplankton abundance generally reflects changes in the abundance of phytoplankton. Copepods are one of the most common types of zooplankton occurring within San Francisco Bay. Other typical zooplankton include early free-swimming stages of barnacles, polychaete larvae, gastropod veliger larvae, juvenile fish, fish eggs, early life stages of crabs and shrimp, and protozoans (USFWS 1986; USACE 1979; USACE and Port of Oakland 1998). These larvae are more likely to be abundant in the shallow-water habitats, especially within eelgrass beds, than in deep water locations within San Francisco Bay. The copepod species, *Acartia* spp., are very abundant in parts of the South Bay, San Pablo Bay and Suisun Bay, particularly in the late spring and early summer (USFWS 1986; USACE and Port of Oakland 1998). *Eurytemora affinis*, which serves as a food source for juvenile fish and crustaceans, has been one of the most abundant copepods in Suisun Bay. However, populations have declined, while populations of two introduced species (*Sinocalanus doerri* and *Pseudodiaptomous forbesi*) have risen (SFEP 2000). The opposum shrimp, *Neomysis* *mercedis*, is food to a number of fish and invertebrates, and tends to be particularly abundant in Suisun Bay and the Delta (USFWS 1986). Within Central Bay, there may also be temporary increases in medusae (e.g., jellyfish) and ctenophores (USACE and Port of Oakland 1998). These would likely be present in both deep and shallow-water habitats.

4.2.1.2 Aquatic Plants

Aquatic plants present within San Francisco Bay include various macroalgal species, eelgrass, and tidal marsh species. Approximately 162 species of macroalgae occur within the estuary. Some of the more common and widely distributed species include the green algae *Enteromorpha clathrata*, *E. intestinalis*, *E. linza*, *Ulva angusta*, *Ulva lactuca*, *Cladophora sericea*, and the red algaes *Plysiphonia denudata* and *Antithamnion kylinii* (Nichols and Pamatmat 1988). These are generally found in the central and northern regions of the Bay on hard-bottom substrates including rock outcrops, coarse sediments, and physical structures such as docks and piers (USACE et al. 1998). Macroalgae require light for primary production and therefore the most species are found in shallow-water habitats. However, some species, such as kelp, are also found in deeper water locations where the water clarity is sufficient to allow for adequate light penetration for photosynthesis to occur. During the summer, drifting macroalgae, which have detached from growing plants, accumulate in intertidal areas (Nichols and Pamatmat 1988).

Eelgrass (*Zostera marina*) provides an important habitat within the San Francisco Bay estuary (Figure 8). Eelgrass beds are highly productive and serve as habitat for epiphytes, invertebrates, and fish. A variety of fish species use eelgrass as a nursery area, and for foraging and spawning. Various bird species also forage for fish within the beds (USACE et al. 1998).

Due to light requirements for photosynthetic activity, eelgrass beds are present within less turbid shallow-water habitats (generally <10 feet deep) within San Francisco Bay. They are primarily found in the Central Bay where salinity is the highest. The beds are located in low-energy areas, where the substrate is mud, or mixed sand and mud (USACE et al. 1998).

There are at least 17 separate eelgrass beds, covering an area of approximately 53 hectares, within Central Bay (USACE et al. 1998). Within San Pablo Bay, eelgrass is present in the southern portion of the bay, just north of Point San Pablo. Aerial surveys have estimated these beds to be approximately 50 hectares in size (USACE et al. 1998). Other eelgrass beds are present along the shoreline west of Point San Pablo, south to Richmond Harbor. In the South Bay, eelgrass beds are present at the north end of the bay off of Alameda and Bay Farm Island.

Tidal marshes also provide valuable habitat for fish and wildlife within the San Francisco Bay estuary. They occur at a number of locations along the margins of the South Bay and San Pablo Bay, within the Delta, and within Suisun Marsh (USACE et al. 1998). Tidal salt marshes occur within more saline areas of the Bay, and tidal brackish marshes occur in areas where there is high freshwater input, such as in Suisun Bay, near the mouths of the Petaluma and Napa rivers, and in areas within the South Bay. The marshes consist of broad vegetated areas incised by a network of tidal channels. Other habitat components include creeks, ponds, and transitional pannes. The plant species composition within the marshes is generally related to tidal elevation, and is characterized by three general zones of vegetation: low tidal marsh, middle tidal marsh, and high tidal marsh (SFEI 1998).

Within San Francisco Bay salt marshes, the dominant plant species are cordgrass (*Spartina* sp.) and common pickleweed (*Salicornia virginica*). Cordgrass is typically the dominant marsh plant species on broad tidal mudflats located at the fringes of the marsh plains, and within the low tidal marsh areas. Pickleweed tends to occur midway within this tidal range, and typically is the dominant plant species in the middle tidal area (areas between mean high water and mean higher high water) of the salt marshes. Pickleweed is also common in the high tidal salt marsh, but at this tidal elevation a number of other marsh plant species are also prevalent. These include saltgrass (*Distichlis spicata*), salt bush (*Atriplex* sp.), and alkali heath (*Frankenia salina*). Other common salt marsh species include fat hen, marsh rosemary (*Limonium californicum*), and jaumea (*Jaumea carnosa*). Salt marsh dodder (*Cuscuta salina*), a parasite on pickleweed, occurs in large sheets in some South Bay marshes (SFEI 1998). Large and microscopic algae also occur within salt marshes.

The predominant plant species within tidal brackish marshes differ from those found in salt marshes. Common species found in the lower tidal, middle tidal, and high tidal brackish marsh areas are described in section 4.1.6 above. Among these are cattails, California bulrush, spike rush, Baltic rush, silverweed, saltgrass, and pickleweed (SFEI 1998).

4.2.1.3 Benthic Invertebrates

Benthic invertebrate species distributions within San Francisco Bay are strongly influenced by the temporal variations of salinity within the Bay, the substrate type within a given area, and the presence of exotic species (Nichols and Patmatmat 1988). For example, within the deeper, more saline Central Bay, the benthic community is more typical of marine communities. In other areas within the Bay, particularly where there is high freshwater input (e.g., Suisun Bay), the benthic communities tend to have a lower diversity and are dominated by a few species that are particularly tolerant of wide salinity changes.

Benthic invertebrate species distributions have been influenced by the presence of exotic species. For example, the native hornsnail (*Cerithidea californica*) has been restricted to marsh pannes by the competitive interaction of the mudsnail, *Ilyanassa obsoleta* (Nichols and Pamatmat 1988). Another example is the introduction of the Asian clam, *Potamocorbula amurensis*, which now dominates most of the benthic communities in San Pablo and Suisun Bay. The existing benthic community in Suisun Bay largely disappeared with the introduction of *P. amurensis* (USACE et al. 1998; SWRCB and CalEPA 1995). A variety of the exotic species within San Francisco Bay were introduced when oysters were imported from Mexico, the Pacific Northwest, Japan, and the east coast in attempts to establish better tasting species for commercial fisheries within the Bay Area. Others were attached to ship hulls or within ship ballast and released into the Bay. At least 100 species have been introduced, and the majority of the common macroinvertebrate species present in the inner shallows of San Francisco Bay are introduced species. There are some areas such as the Central Bay where native species predominate. Many of the introduced species are opportunistic colonizers, have short life spans, produce large numbers of young, and tolerate a wide range of physical habitat conditions (e.g., salinity, temperature, substrate types), and therefore have been highly successful in becoming established within the Bay (Nichols and Pamatmat 1988).

Benthic communities within the Bay also vary according to whether the substrate is comprised of sandy sediments, mud, gravels or rocks, or if it contains shell deposits such as found in the South Bay. Rocky areas in San Francisco Bay are inhabited by typical hard-substrate organisms, including the mussel *Mytilus edulis* or *Mytilus galloprovincialis* (Nichols and Pamatmat 1988; USACE et al. 1998). This type of substrate is generally inhabited by sessile organisms such as bryozoans, sponges, and tunicates, in addition to the mussels (USACE and Port of Oakland 1998).

Deep water, coarse-grained sediments are generally found in highly dynamic areas within San Francisco Bay (e.g., Central Bay). The benthic community found within large sand waves formed in some areas in the Central Bay is generally comprised of species found in sandy substrates found along the outer coast (Nichols and Pamatmat 1988). The polychaetes *Armandia brevis*, *Mediomastus* sp., *Siphones missionensis*, and *Glycinde picta* are common in the deep sandy substrates of the Central Bay. Other common species include the amphipod *Foxiphalus obtusidens* and the crab *Cancer gracilis* (USACE et al. 1998). Surveys conducted for a pilot study conducted for the Regional Monitoring Program (RMP) on benthic macrofaunal assemblages in the San Francisco Estuary included an area of strong currents and sandy substrates. Only four to six species inhabited this area, and their respective abundances were low. Tubificid oligochaetes and *P. amurensis* were among the organisms found at this location (Thompson et al. 1994).

In areas where shell deposits are prevalent in the substrate (e.g., South Bay), species that are typically found on hard bottom substrates are present. Among these include the gastropods *Crepidula* spp. and *Urosalpinx cinerea*; the tunicate *Molgula manhattensis*; the mussel *Musculista senhousia*; and a variety of hydrozoans, bryozoans, and anemones. The introduced clam, *Venerupis philippinarum,* is also abundant in the shelly deposits (Nichols and Pamatmat 1988).

A large portion of both San Pablo Bay and the South Bay are comprised of shallow-water, soft-bottom habitat, although deep-water, fine-grained areas are also present, particularly within the South Bay. The species dominating the benthic community soft-bottom habitats in these two embayments are comparable (Nichols and Pamatmat 1988). One of the most abundant species present is the introduced clam *Potamocorbula amurensis* (Thompson et al. 1994). Typical mollusk species in the shallow subtidal habitats include the bivalves *Macoma balthica*, *Mya arenaria, Gemma gemma*, *Musculista senhousia*, and *Venerupis philippinarum* (Nichols and Pamatmat 1988). These species are also abundant in the deep-water locations (Hopkins 1986). *Macoma balthica* is the predominant benthic species found in the intertidal areas of San Pablo Bay (Nichols and Pamatmat 1988). Common amphipods include *Ampelisca abdita*, *Grandidierella japonica*, and *Corophium* spp. (Thompson et al. 1994; Nichols and Pamatmat 1988). The polychaetes *Streblospio benedicti*, *Heteromastus filiformis*, *Glycinde* sp., and several species of the genus *Polydora* are also common (Nichols and Pamatmat 1988). In addition, the tube-dwelling polychaete *Asychis elongata* is abundant in subtidal mud areas of the South Bay (Nichols and Pamatmat 1988).

Because there are large variations in salinity within Suisun Bay, the area is inhabited by few permanent benthic species that can tolerate the salinity changes. Among these include the clams *Macoma balthica* and *Mya arenaria*, the amphipods *Corophium stimpsoni* and *C. spinicorne*, and the annelids *Nereis succinea* and *Limnodrilus hoffmeisteri* (Nichols and Pamatmat 1988). During periods of high run-off, the freshwater clam *Corbicula fluminea* may even occur within the Bay. The amphipod *Ampelisca abdita* and polychaete *Streblospio benedicti*, which are generally not found east of Carquinez Strait, may occur within Suisun Bay during periods of low freshwater flow (Nichols and Pamatmat 1988).

Because of maintenance dredging within the existing navigation channels, the benthic community is likely unstable and species expected to be present are those most likely to adapt to changes or disruption to their environment. Opportunistic species such as small, near-surface dwelling spionid and capitellid polychaetes are likely to be present in these areas. Diversity would be expected to be low in the channel areas (USACE and Contra Costa County 1997; USACE and Port of Oakland 1998).

Common benthic invertebrates that occur within tidal marshes include the amphipods *Traskorchestia traskiana*, *Corophium spinicorne*, and *Grandidierella japonica*; several snail species including the native species *Cerithidea californica*, *Assiminea californica*, and *Ovatella myostotis*; and the native shore crab *Hemigrapsus oregonensis* (Nichols and Pamatmat 1988, USACE et al. 1998).

The eastern ribbed mussel (*Guekensia demissa = Ischadium demissum*) populates the bayward edges of marshes throughout the Bay. The isopod, *Sphaeroma quoyana*, burrows into slopes at marsh edges in a number of locations in South Bay and San Pablo Bay. The mudsnail, *Ilyanassa obsoleta* isalso found at the base of these slopes, as well as in the tidal channels of the marshes. The ribbed mussel, isopod, and mudsnail are all introduced species within San Francisco Bay (Nichols and Pamatmat 1988). Other common species occurring in tidal marsh habitats include the clams *Macoma balthica*, *Potamocorbula amurensis*, and *Mya arenaria*. The asian clam, *Potamocorbula amurensis*, has become the dominant species in many of the San Francisco Bay estuary marsh habitats (Nichols and Pamatmat 1988, USACE et al. 1998).

Typical benthic epifauna throughout the San Francisco Bay estuary include mud snails (*Nassarius obsoletus*), isopods (*Syndotes* sp.), shrimp (*Crangon franciscorum* and *Crangon nigricauda*), and crabs (*Cancer* sp.). The commercially important Dungeness crabs (*Cancer magister*) use the Bay as a nursery area. They are generally found up to Carquinez Strait (USACE 1998). They are likely to be present in each of the habitats under consideration.

4.2.1.4 Fish

Fish occurring within San Francisco Bay include a variety of estuarine, marine, and anadromous fish species. Among these are various flatfish, surfperch, gobies, sculpin, bait and forage fish (e.g. anchovies, herring, smelt), pipefish, croakers, silversides, sharks, and rays. Anadromous fish that pass through the Bay to spawn upstream, particularly in the Sacramento-San Joaquin river system, include striped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), chinook salmon (*Oncorhynchus tshawytscha*), white and green sturgeon (*Acipenser transmontanus* and *Acipenser medirostris*), and steelhead trout (*Onchorhynchus mykiss mykiss*). These fish may occur in the majority of the deep-water and shallow-water habitats under consideration, although some, such as juvenile fish, are likely to be more common in the shallow water environment than in deep water.

Within San Francisco Bay, flatfish that are common in areas containing sandy-silt sediments (both shallow and deep water) include English sole (*Parophyrs vetulis*), starry flounder (*Platichthys stellatus*), California halibut (*Paralichthys californicus*), and diamond turbot (*Hypsopsetta guttulata*) (USACE 1992). Halibut, striped bass, rockfish (*Sebastes* sp.), and lingcod (*Ophiodon elongatus*) are common in the deep-water, sandy substrate and rock outcrop areas of the Central Bay (USACE et al. 1998). Other common bottom fish include bay gobies (*Lepidogobius lepidus*), Pacific staghorn sculpin (*Leptocottus armatus*), plainfin midshipman (*Porichthys notatus*), and the introduced goby species, the yellowfin goby (*Acanthogobius flavimanus*) and chameleon goby (*Tridentiger trigonocephalus*) (USACE et al. 1998). These species are likely present in each of the deep-water habitats under consideration. Adults of the anadromous fish migrating through San Francisco Bay, are likely to occur within each of the deep-water habitats, although they are less likely to occur in the South Bay deep-water habitats containing shell debris, since those areas are outside of the main migration route of these fish. However, American shad and striped bass have been observed in the South Bay in the vicinity of the Bay Farm Borrow Area (SAIC 1994).

Within shallow-water habitats, English sole, starry flounder, bay goby, Northern anchovy (*Engraulis mordax*), and shiner surfperch (*Cymatogaster aggregata*) were found to be the dominant species in shallow subtidal areas in the vicinity of Oakland Harbor (USACE and Port of Oakland 1998). In addition, white croakers (*Genyonemus lineatus*) are often very abundant in shallow-water areas of the South Bay and San Pablo Bay, and spawn nearshore, particularly in the late fall and winter (Smith and Kato 1979; U.S. Navy 1993). Brown smoothhound (*Mustelus henlei*) and leopard sharks (*Triakis semifasciata*) are abundant in the intertidal mudflats (USACE et al. 1998). Pacific herring (*Clupea pallasi*) enter the estuary and spawn in the winter and early spring, particularly in rocky areas, along seaweed (e.g. *Gracillaria*) or eelgrass covered substrates, on pilings, and on sandy beaches (U.S. Navy 1993; USACE and Port of Oakland 1998). Herring apparently do not spawn on muddy substrates present on the east side of the Bay (USACE 1998). Juvenile herring are typically found in shallow-water habitats throughout San Francisco Bay and move to deeper-water habitats as they grow larger (USACE 1998). Juveniles of the anadromous fish species present within San Francisco Bay utilize the shallow-water habitat as a nursery habitat, particularly in San Pablo and Suisun bays.

Dominant fish species observed during surveys conducted in Oakland Inner and Outer Harbor navigation channels included plainfin midshipman, staghorn sculpin, bay goby, speckled sanddab (*Citharichthys stigmaeus*), shiner surfperch, English sole, Northern anchovy, white croakers, and topsmelt (*Antherinops affinis*). Pacific tomcod (*Microgadus proximus*) was also abundant during the spring. These species are common in various locations throughout San Francisco Bay (USACE and Port of Oakland 1998). The various anadromous species may be present in the vicinity of the navigation channels, particularly as adults during their migration upstream.

Tidal marshes within the San Francisco Bay estuary also provide valuable habitat (e.g., cover, forage, and nursery habitat) for a variety of fish species, including special status fish species. Typical fish species occurring in the marshes include arrow gobies (*Clevelandia ios*), yellowfin gobies, topsmelt, Pacific staghorn sculpin, tule perch (*Hysterocarpus traskii)*, catfish (*Ictalurus* sp.), and mosquitofish (*Gambusia affinis*). The commercially important striped bass, and the special status species, winter-run chinook salmon, Delta smelt, longfin smelt, Sacramento splittail, green sturgeon, and tidewater gobies, utilize tidal marshes as rearing and foraging habitat.

4.2.1.5 Aquatic Birds

Marine birds occurring in San Francisco Bay include both migratory and year-round residents. Species within the estuary in Central Bay include a variety of cormorants, gulls, scoters, murres, guillemots, grebes, among others. Similar species are also found throughout the Bay, although diving ducks such as scaups (*Aythya* spp.) would more likely be present in the less dynamic areas of the estuary including San Pablo Bay, South Bay, and the harbors. Wintering species occurring in the area include the common loon (*Gavia immer*), surf scoter (*Melanitta perspicillata*), and western grebe (*Aechmophorus occidentalis*) (USFWS 1986; USFWS 1995). The waterfowl are likely to be more abundant in the shallow-water habitats, although they also occur in deep-water environments. For example, grebes were abundant in shoal areas of Oakland Outer Harbor, as well as in the deep dredged areas (USACE and Port of Oakland 1998). Cormorants and gull species are likely found in each of the deep-water habitats under consideration, including the navigation channels, as well as the shallow-water areas.

The least tern (*Sterna antillarum*) is a spring and summer migrant that breeds at specific locations within the estuary (see section 4.2.1.7 below). Shorebirds, such as sanderlings (*Calidris alba*) and dunlin (*Calidris alpina*), are also present within the estuary shallow-water habitats, feeding on small clams, snails, and worms on tideflats (USFWS 1986; USFWS 1995).

A number of bird species utilize the tidal marshes located within the Bay estuary as resting, nesting, cover, and foraging habitat. Shorebirds, such as sandpipers (*Calidris* sp.) and dunlin, forage within the marshes, and migratory waterfowl rest and forage within the tidal channels. The California clapper rail (*Rallus longirostris obsoletus*), California black rail (*Laterallus jamaicensis*), salt marsh yellowthroat (*Geothylpis trichas sinuosa*), willet (*Catoptrophorus semipalmatus*), song sparrows

(*Melospiza melodia* sp.), northern harrier (*Circus cyaneus*), red-tailed hawk (*Buteo jamaicensis*), and short-eared owl (*Asio flammeus*) are among the variety of bird species occurring within the tidal marsh habitats (USACE and Contra Costa County 1997, USACE et al. 1998, SFEI 1998).

4.2.1.6 Marine Mammals

Marine mammals that occur within the Estuary include the California sea lion (*Zalophus californianus*), harbor seals (*Phoca vitulina*), and harbor porpoises (*Phocoena phocoena*). Harbor porpoises are usually found in the Central Bay area, particularly near the entrance to the estuary at the Golden Gate Bridge. The sea lions and seals are found in various locations throughout the Bay, including harbor waterways. However, seal abundance is relatively low in the harbors due to frequent disturbance and human activity. The mammals are likely to occur in any of the various deep-water and shallow-water habitats under consideration. Harbor seals also utilize tidal marshes as resting or haul out sites during high tides. This occurs particularly in marsh areas adjacent to sloughs in the South Bay (SFEI 1998).

4.2.1.7 Threatened, Endangered, and Sensitive Species

Several federal- or state-listed threatened or endangered species occur either occasionally or periodically within San Francisco Bay. These species include the California least tern (*Sterna antillarum browni*), the California brown pelican (*Pelecanus occidentalis californicus*), the Western snowy plover (*Charadrius alexandrinus nivosus*), the winter-run chinook salmon (*Onchorhyncus tshawytscha*), coho salmon (*Onchorhynchus kisutch*), steelhead trout (*Onchorhynchus mykiss irideus*), the delta smelt (*Hypomesus transpacificus*), and the tidewater goby (*Eucyclogobius newberryi*). Other sensitive species include the Sacramento splittail (*Pogonichthys macrolepidotus*), a federally proposed threatened species, and the candidate species green sturgeon (*Acipenser medirostris*) and longfin smelt (*Spirinchus thaleichthys*). A number of special status species such as the endangered California clapper rail and salt marsh harvest mouse (*Reithrodontomys raviventris*) occur within the tidal marsh areas. The listed status of these species, their feeding habits, their spawning or breeding habitats/seasons, and other information is provided in Table 4.2-1. The likely occurrence of these species within the deep-water, navigation channel, and shallow-water habitats under consideration is discussed in more detail below.

Table 4.2-1. Threatened, Endangered, and Sensitive Animal Species Occurring within San Francisco Bay

(page 1 of 6)

Species	*Status*	*Forage Food*	*Foraging Habitat and Feeding Behavior*	*Breed/Spawn Habitat/Period*	*Comments*
BIRDS					
California least tern (*Sterna antillarum browni*)	FE, SE	Feed on fish that are small, abundant, schooling, near-surface, planktivorous feeders such as: Northern anchovy, topsmelt, Pacific herring, jacksmelt, shiner.	2-3 mile radius from nest location near breakwaters and shallows; dives for food.	Mid-May to August near feeding areas, open flat beach, sand flat, and bare dirt; within SF Bay, nest at the Naval Air Station (NAS) Alameda.	The nesting colony of least terns at NAS Alameda is the largest known colony north of San Luis Obispo County, and has been active for at least 10 years. The terns generally migrate from the SF Bay winter south of the U.S.
California brown pelican *(Pelecanus occidentalis californicus)*	FE, SE	Fish, such as: anchovies, Pacific saury, rockfish.	Open waters of SF Bay; dives for food.	Nest in the Northern Channel Islands; roost on coastal rocks during non-breeding season.	Several thousand summer in SF area; important habitat includes offshore rocks, islands, sandbars, breakwaters, and pilings. The largest roost within SF Bay is on the breakwaters to the south of NAS Alameda.
Western snowy plover (*Charadrius alexandrinus nivosus)*	FT, SC	Feed on intertidal and supratidal invertebrates. Feeding is diurnal.	Occupies sandy beaches and intertidal areas of marine and estuarine habitats; also occurs in some inland areas.	Nests are usually established in sparsely to non-vegetated areas of sandy beaches and estuaries.	Winter in the San Francisco Bay area.
California clapper rail (*Rallus longirostris obsoletus*	FE, SE	Probe for invertebrates and seeds in soft mud at low tide.	Feed in the lower marsh zone, including tidal sloughs and channels.	Build nests near tidal sloughs, using cordgrass, pickleweed, and other plants. Require dense vegetation for nesting and cover.	Found mainly in the upper to lower zones of salt marshes dominated by pickleweed and cordgrass, although some also live in brackish marshes.

Table 4.2-1. Threatened, Endangered, and Sensitive Animal Species Occurring within San Francisco Bay

Species	*Status*	*Forage Food*	*Foraging Habitat and Feeding Behavior*	*Breed/Spawn Habitat/Period*	*Comments*
			BIRDS		
California Black Rail (*Laterallus jamaicensis coturniculus*)	FC1, ST	Insects, crustaceans, arthropods and seeds of aquatic plants.	Feed in the lower marsh zone, including tidal sloughs and channels.	Use grass blades to weave nests at the base of marsh plants; require dense vegetation for nesting and cover. Most often nest in tidal salt marshes dominated by pickleweed, but some found in brackish and freshwater marshes. Prefer well-developed marsh with stable water levels; therefore marsh restoration activities may not benefit the rail for many years.	Adults are believed to be relatively non-migratory. Principle cause of decline and barrier to recovery is loss and degradation of the subspecies' high-marsh wetland habitat, a transition zone between tidal and upland areas; consequently, more than 80% of remaining California black rails are concentrated in northern SF Bay. Very shy bird, difficult to detect except by its call.
			FISH		
Winter-run chinook salmon (*Oncorhynchus tshawytscha*)	FE, SE	<u>Fry – zooplankton</u> (especially Cladocera and Copepoda), and dipteran insects	Feed in schools in littoral or shallow sublittoral habitats such as salt marshes, mudflats and other intertidal areas.	The adults are present in the SF Bay area from Nov. to May. Spawning is limited to the Sacramento River (below the Keswick Dam) from mid-April to August.	
		<u>Smolts – gammarid</u> amphipods, larval fish, and crustaceans	Primarily in shallow brackish waters.	Smolts migrate from Nov. through May, with peak abundance occurring from January to April.	
		<u>Marine-dwelling juvenile –</u> fish, crustaceans, and insects	Open ocean (over continental shelf waters), various locations in SF Bay, particularly along migration route.	Migrating adults have also been caught in Suisun Bay in October. This species differs from fall- run chinook in that they arrive in the upper river up to several weeks prior to spawning and hold up in deep pools awaiting sexual maturity.	
			FISH		
		<u>Adult – pelagic</u> — crustaceans (krill, larval crabs, and fish)	Open ocean until spawning time; then found in SF Bay and Sacramento River. They do not feed from the time they leave the ocean until they spawn, 5-8 months later.		

Table 4.2-1. Threatened, Endangered, and Sensitive Animal Species Occurring within San Francisco Bay

Species	*Status*	*Forage Food*	*Foraging Habitat and Feeding Behavior*	*Breed/Spawn Habitat/Period*	*Comments*
Central California Coho Salmon (*Oncorhynchus kisutch*)	FT, SE	Juveniles feed on insects and crustaceans. Adults are primarily piscivores, although shrimp, crabs, and other pelagic invertebrates can be important food in some areas.	Juveniles prefer deep (≥1 m), well-shaded pools in streams with plenty of overhead cover. They move into deeper water as they grow.	Return to parent streams after spending 1-2 years in the ocean. Prefer to spawn in small coastal creeks or tributary headwaters of larger rivers. Spawning migrations generally occur in Sept. to late Dec., and spawning occurs from Oct. to Mar (peak Nov-Jan). Outmigration of juveniles begins in late March or April and peaks mid-May.	The Sacramento River and tributaries to SF Bay are believed to have supported coho runs at one time, but these runs are believed to have been extirpated, or nearly so.
FISH					
Steelhead Trout (*Oncorhynchus mykiss irideus*)	FPE, ST	Juveniles likely feed on insects and small crustaceans. Adults feed on fish and likely feed on other pelagic invertebrates. Migrating adults seldom feed: stomachs examined are empty or contain only a few aquatic insect larvae.	Juveniles likely prefer shallow water habitat and move out into deeper water as they grow. Habitat requirements are similar to those of Chinook salmon.	Steelhead typically migrate to marine waters after spending 2 years in fresh water. Return to their natural stream to spawn as 4-5 year olds. They are capable of spawning more than once (usually twice) before they die. Central California ESU: Adults migrate Oct-June; spawning occurs Nov-April (peak Feb-Mar) Little is known about smolt outmigration. Central Valley ESU: In upper Sacramento basin, adults enter the river from July–May (peak Sept-Feb). Spawning begins in late Dec. and can extend into April. Little is known about the timing of runs in the San Joaquin system, or about smolt outmigration.	Fish from two ESUs, Central California Coast and Central Valley ESUs may occur in the area. Central California Coast ESU extends from the Russian River in Sonoma County to Soquel Creek in Santa Cruz County, including drainages of San Francisco and San Pablo bays. The Napa and Petaluma rivers and Sonoma Creek support steelhead runs. Central Valley ESU includes the Sacramento and San Joaquin rivers and tributaries. Steelhead appear to be limited to the Stanislaus, Tuolomne, and Merced rivers, and the mainstem of the San Joaquin River to the confluence of the Merced River.

Table 4.2-1. Threatened, Endangered, and Sensitive Animal Species Occurring within San Francisco Bay

Species	*Status*	*Forage Food*	*Foraging Habitat and Feeding Behavior*	*Breed/Spawn Habitat/Period*	*Comments*
Delta smelt (*Hypomesus transpacificus*)	FT, ST	Zooplankton (e.g. the copepods *Eurytemora affinis* and *Cyclops* sp.)	Planktonic smelt larvae and juveniles are trans-ported downstream to the estuarine mixing zone.	1-year life span — adults typically die after spawning. They spawn Feb-Jun, in open water of dead-end sloughs and channel edge-waters of Sacramento-San Joaquin Delta. Eggs attach to rocks, tree roots, gravel and submerged branches and vegetation.	Occur in Bay-Delta Estuary; during periods of high outflow, they may be found in San Pablo Bay, but are generally not found further downstream than Suisun Bay.
FISH					
Tidewater goby (*Eucyclogobius newberryi*)	FE, SC	Small invertebrates and insect larvae	Coastal lagoons, marshes, creeks, marine to freshwater; larvae are found foraging among vegetated shallows.	No specific season; 1-year life span	
Sacramento splittail (*Pogonichthys macrolepidotus*)	FPT, SC	Benthic invertebrates and mysid shrimp (*Neomysis mercedis*)	Feed primarily in the Sacramento River and the Delta, Suisun Bay, Suisun Marsh, and Napa Marsh. Tolerant of brackish water conditions, and can often be found in San Pablo Bay following winter high-flow periods when waters are relatively dilute.	Similar to delta smelt; congregates at dead-end sloughs of the Delta and spawns on flooded streambank vegetation or beds of aquatic plants; spawns Feb-April.	Endemic to the San Joaquin Valley
Green sturgeon (*Acipenser medirostris*)	FC	As juveniles, feed on benthic invertebrates, small crustaceans (*Neomysis* and *Corophium*); change to larger prey such as clams, shrimp, crabs, polychaetes, and fish as they grow larger	Juveniles grow and feed in the San Francisco, San Pablo and Suisun Bay estuaries.	Sacramento River, March through July. Preferred spawning substrate is likely large cobble, but can range from clean sand to bedrock.	Juveniles do not migrate to the ocean until 4-6 years old
Longfin smelt (*Spirinchus thaleichthys*)	FC, SC	Feed primarily on mysid shrimp (*Neomysis mercedis*)	Found in brackish waters; SF Bay-Delta estuary; larva are transported downstream to the lower Delta, Suisun Bay and San Pablo. Adults will also move into SF Bay and have been observed in the South Bay.	Spawn Feb-April in freshwater portions of Sacramento and San Joaquin rivers, the Delta, and Suisun Bay.	High salinity tolerance

Table 4.2-1. Threatened, Endangered, and Sensitive Animal Species Occurring within San Francisco Bay

Species	*Status*	*Forage Food*	*Foraging Habitat and Feeding Behavior*	*Breed/Spawn Habitat/Period*	*Comments*
MAMMALS					
Salt marsh harvest mouse (Reithrodontomys raviventris)	FE, SE	Feed on seeds and green vegetation. Capable of drinking water with relatively high salt content.	Inhabit and forage in the middle to upper levels of dense pickleweed stands in tidal and diked coastal salt marshes.	Reproduce throughout much of the year, although populations peak in summer and fall. Northern subspecies may build nests or use old birds nests on the ground. Bear 1-2 litters / year (litter size is 3-4 offspring).	Edemic to San Francisco Bay area.

Notes:

1. SF = San Francisco
2. Under status column, the following abbreviations have been used:

FT= Federal, threatened
FE = Federal, endangered
FC = Federal, species of concern
FC1 = Federal, candidate
FPT = Federal, proposed threatened
FPE = Federal, proposed endangered

ST = State, threatened
SE = State, endangered
SC = State, species of concern

Source: USACE et al. 1998, BioSystems 1994, and Moyle et al. 1995.

California least terns primarily forage along the breakwaters and shallows of the southern shoreline of Naval Air Station (NAS) Alameda and Ballena Bay, near their nesting site at the Alameda Naval Air Station (USACE 1992; USACE 1984). They tend to forage (within a 2 to 3 mile radius) in the shallows in this area because the fish are more visible. However, they have been observed foraging in the vicinity of the Bay Farm Borrow area, which contains deep-water, fine-grained sediments, and occasionally forage in other nearby areas such as the Oakland Harbor navigation channel (SAIC 1993).

California brown pelicans are likely to occur in each of the habitats under consideration. They use the open waters of the Central Bay for feeding and roost on rocks, jetties, and piers in the area. The largest brown pelican roost within the Bay is located on the breakwaters to the south of NAS Alameda, and they are known to forage along the Oakland Inner Harbor Channel (USACE 1992).

Western snowy plovers are small shorebirds that typically occupy sandy beaches and intertidal areas of marine and estuarine habitats. They feed on intertidal and supratidal invertebrates, and nest in sparsely to non-vegetated areas of sandy beaches and estuaries. Because these are shorebirds, they would not be present in the deep-water habitats under consideration, or in navigation channels.

Winter-run chinook salmon are an anadromous species that pass through the Sacramento-San Joaquin Delta, San Pablo Bay, and San Francisco Bay during their upstream and downstream migrations (J. Turner, California Department of Fish and Game [CDFG] as cited in EPA 1993). Chinook salmon fry feed mainly in shallow sublittoral habitats such as salt marshes, mudflats, and other intertidal areas. Smolts are also more likely to be found in the shallow-water habitats of San Francisco Bay, particularly in the North Bay areas. Juvenile salmon would move out into deeper water as they grow. Adults are likely to be present in both shallow and deep-water habitats, as well as the navigation channel.

Similar to the chinook salmon, steelhead trout are an anadromous fish species that migrate through San Francisco Bay to spawn in the San Joaquin River and its tributaries and other drainages in San Francisco and San Pablo Bays (USACE et al. 1998, USACE and Port of Oakland 1998). Their general habitat requirements are comparable to that of chinook salmon, although juvenile fish generally do not migrate downstream to the ocean until they are 2 years old (USACE and Port of Oakland 1998). Smolts are likely to be found in nearshore shallow-water habitats and would move out into deep-water as they grow. Adults are likely to be present in both shallow and deep-water habitats, including navigation channels.

Coho salmon are also an anadromous fish species that have spawned in San Francisco Bay tributaries and the Sacramento River. Fish survey counts conducted in these areas did not indicate the presence of coho salmon. Coho runs into the San Francisco Bay tributaries are believed to be nearly extirpated, and very few coho salmon remain in the Scaramento River drainage (USACE et al 1998). Therefore, few, if any, coho salmon are expected to be present in locations where habitat enhancement may occur. Should they occur in the San Francisco Bay area, their presence in the shallow and deep-water habitats would likely be comparable to the chinook salmon and steelhead trout.

Delta smelt occur only in the Bay-Delta estuary. They are found in open surface and shoal waters of the channels and Suisun Bay including the tidal marsh channels (SWRCB and CalEPA 1995, USACE et al. 1998). Although during periods of high outflow, they may be found in San Pablo Bay, they generally are not found further downstream than Suisun Bay (SWRCB and CalEPA

1995). They likely occur in the fine-grained and coarse-grained deep-water habitats within these areas.

The Sacramento splittail is found primarily in the Sacramento River and the Delta, Suisun Bay, Suisun Marsh, and Napa Marsh. The splittail is tolerant of brackish water conditions, and can often be found in Suisun Bay, San Pablo Bay, and Carquinez Strait following winter high-flow periods, when water in these areas is relatively dilute (SWRCB and CalEPA 1995; Meng and Moyle 1995). Similar to the delta smelt, this species occurs in the shallow waters of the Delta and Suisun Bay (particularly during the larval stage), but may occasionally occur within the fine-grained or coarse-grained deep-water habitats of Carquinez Strait and San Pablo Bay during periods of high run-off.

Tidewater gobies are found primarily in coastal lagoons, marshes, and creeks, and can tolerate a wide range of salinities (from freshwater to marine). Larvae are usually found among vegetated shallows until the fish grow larger (BioSystems 1994).

The green sturgeon migrates through the Bay-Delta estuary to spawn in the Sacramento River. Therefore, green sturgeons may occur within each of the deep and shallow-water habitats under consideration. They also occur within tidal marsh channels within the Bay (USACE et al. 1998).

Longfin smelt occur in the Bay-Delta estuary, and spawn in freshwater portions of the lower Sacramento and San Joaquin rivers, the Delta, and Suisun Bay, including tidal marshes within these areas. The larvae are transported downstream to the lower Delta, Suisun Bay, and San Pablo Bay, and are likely to occur primarily within the shallow-water habitats within these embayments. Adult longfin smelt will also move into San Francisco Bay (SWRCB and CalEPA 1995). Therefore, they may occur within the various deep-water habitats under consideration, including the navigation channels.

In addition to the special status fish species indicated above, a variety of special status plant and animal species occur within the tidal marsh areas of the San Francisco Bay estuary. The Point Reyes bird's beak (*Cordylanthys maritimus* ssp. *palustris*) is a rare plant species that may be found within Richardson and San Pablo bays, and Suisun Marsh. Other rare plant species that may occur within the Bay Area tidal marshes include the soft bird's beak (*Cordylanthyus mollis* ssp. *mollis*), Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum*), Mason's lileaopsis (*Mason's lilaeopsis*), the Delta pea (*Lathyrus jepsonii* var. *jepsonii*), and California seablite (*Suaeda californica*). Special status bird species include the California clapper rail, black rail, salt marsh common yellowthroat, San Pablo or Suisun song sparrow (*Melospiza melodia samuelis*), and Alameda song sparrow *(Melospiza melodia maxillaries*). Mammal species that are dependent upon the tidal marshes include the salt marsh harvest mouse, salt marsh vagrant shrew (*Sorex vagrans halicoetes*), and Suisun ornate shrew (*Sorex ornatus sinuosus*) (SFEI 1998, USACE et al. 1998). The majority of these tidal marsh species are considered species of concern either by the state or federal government. The California clapper rail and salt marsh harvest mouse, however, are listed as endangered by both the state and federal government. The California black rail is listed by the state as threatened. Soft bird's peak is listed as endangered by the federal government and rare by the state. Suisun thistle and California seablite are both listed as endangered by the federal government, but do not have a state status.

4.2.2 Water Quality

This section describes the water quality characteristics of the San Francisco Bay. The data have been summarized for shallow/intertidal areas, deep-water areas with fine-grained sediment, and a deep-water area with coarse-grained sediment. Deep-water areas are defined in this document as water depths greater than 20 feet. There are no known data available that describe existing water quality conditions for dredged areas in the Bay. However, it is expected that water quality in the dredged areas would not be significantly different from other nearby deep-water stations.

The most comprehensive data sets describing water quality in the San Francisco Estuary come from the Regional Monitoring Program (RMP) managed by the San Francisco Estuary Institute (SFEI), which has been collecting water quality data since 1993. Conventional water quality parameters, metals, and organic levels were collected for the RMP in February, April, and August 1997; these are the most recent data available from SFEI. These data are presented in Table 4.2-2 and are summarized in the following sections (SFEI 1999). The 1997 RMP water quality stations have been grouped as shallow-water, deep-water fine-grained, and deep-water coarse-grained stations for data presentation. It should be noted that for some water quality parameters, such as salinity, total suspended solids, nutrients, metals, and organics, differences between shallow-water and deep-water areas may be more a function of proximity to point sources or areas of high runoff, rather than a function of water depth.

Salinity

The salinity of water entering the estuary varies greatly. The Sacramento River and eastside streams flowing into the Delta are low in salts, with salinity averaging less than 0.1 parts per thousand (ppt). The salinity of the estuary's northern reach varies considerably and increases along a gradient from the Delta to Central Bay (SFEP 1992). Central Bay water salinities are some of the highest measured in the estuary. An average value of 27 ppt was measured during studies conducted in the 1960s and 1970s (USACE 1976a). The high salinity levels of Central Bay waters are directly influenced by the influx of Pacific Ocean water, which can have salinities as high as 33.2 ppt (Conomos 1979). In the southern reach, salinities remain at near-ocean concentrations during much of the year. Seasonal changes in the salinity distribution within the estuary are controlled mainly by the exchange of ocean and Bay water, and by river inflow (SFEP 1992).

The 1997 RMP measurements of salinity during the three sampling periods in 1997 ranged from 0.5 ppt to 29.9 ppt for shallow/intertidal stations. Deep-water, fine-grained stations ranged from 6.2 to 30 ppt, and the deep-water, coarse-grained station (Red Rock) ranged from 6 to 30.3 ppt (SFEI 1999). According to the 1997 RMP Annual Report, the big storm, which occurred in January 1997, resulted in extremely low salinities in the Bay's surface waters (SFEI 1999). The lowest salinities occurred at stations in the northern reaches of the Bay during the January sampling period. These stations were near areas of high runoff during the big storm of January 1997.

Temperature

The temperature of the estuary's water varies geographically and seasonally. In all parts of the Bay, water temperature is lowest from January to March and highest in the summer and early fall. Temperature is highest in July for most of the Bay, although a temperature maximum in the Central Bay occurs one month later, in August. Central Bay water temperatures are moderated by the entry of Pacific Ocean waters through the Golden Gate (USACE and Contra Costa County

Table 4.2-2. 1997 RMP Water Quality Data for the San Francisco Bay

Parameter	*Shallow/Intertidal Stations* [1]	*Deep Water Fine-grained Stations* [2]	*Deep Water Coarse-grained Station* [3]
CONVENTIONAL PARAMETERS			
Temperature (°C)	9.8-23.3	10-23.4	9.2-17.1
Salinity (ppt)	0.5-29.9	6.2-30	6-30.3
Total Suspended Solids (mg/L)	3-196	1-126	5-20
Dissolved Oxygen (mg/L)	6.1-12.5	6.8-11.5	7.3-9.2
PH	6.5-8.2	7.4-8.3	7.5-7.7
Nitrate (µg/L)	100-4,100	100-900	300
Nitrite (µg/L)	5-136	6-44	8-13
Ammonia (µg/L)	ND-400	ND-200	100
Phosphate (µg/L)	50-700	50-330	50-70
Silicates (µg/L)	100-800	100-600	200-600
METALS (TOTAL OR NEAR TOTAL*) (µg/L)			
Arsenic	1.47-4.76	1.68-4.13	1.62-2.35
Cadmium*	0.03-0.14	0.03-0.14	0.03-0.09
Chromium	0.66-41.37	0.32-17.95	1.49-4.56
Copper*	1.3-10.9	1.2-7.6	1.6-2.8
Lead*	0.27-3.23	0.16-2.77	0.47
Mercury	0.0001-0.0837	0.0011-0.0338	0.0028-0.0062
Nickel	1.9-28.5	1-16.6	2.1-3.8
Selenium	0.09-1.19	0.1-0.63	0.1-0.17
Zinc*	1.4-31.5	0.9-13.5	2.4-4
ORGANICS (TOTAL) (µg/L)			
Total PAHs	12,105-234,390	8,590-105,868	13,750-14,520
Total PCBs	131-4,539	213-1,153	143-325
Total DDTs	223-2,293	150-1,079	252-528
Total Chlordanes	16-478	16-414	73-123

Notes:

1. RMP stations used to characterize shallow/intertidal areas included the following: BD40, BA10, BA20, BA40, BC10, BC30, BC41, BD20, BD30, BF20, and BF40.
2. RMP stations used to characterize deep-water, fine-grained areas included the following: BA30, BB15, BB30, BB70, and BF10.
3. The RMP station used to characterize deep-water, coarse-grained areas was BC60. Refer to the SFEI (1999) document for detailed descriptions of the RMP stations.
4. ND = not detected

Source: SFEI 1999.

1997). The RMP for 1997 found mean temperatures at the shallow water stations to be 10.7°C, 16.6°C, and 20.5°C in January, April, and July/August respectively. Deep-water, fine-grained stations had temperatures of 10.5°C, 16.3°C, and 21.1°C during these same time periods, and the deep-water, coarse-grained station had temperatures of 9.2°C, 14.5°C, and 17.1°C (SFEI 1999).

Dissolved Oxygen

The estuary's waters are well oxygenated, except during the summer in the extreme southern end of South Bay where concentrations are reduced by poor tidal mixing and high water temperatures (SFEP 1992). The winter oxygen concentrations throughout the Bay are notably higher than those during summer, promoted in part by the greater solubility of oxygen in colder water (Conomos 1979). Dissolved oxygen in the Bay is lowest in summer when waters are relatively quiescent and warm, and biological oxygen demand is high (USACE and Contra Costa County 1997). The 1997 RMP data reported dissolved oxygen concentrations ranging from 6.1 to 12.5 mg/L at the shallow-water stations. At the deep-water, fine-grained stations, dissolved oxygen concentrations ranged from 6.8 to 11.5 mg/L, and from 7.3 to 9.2 mg/L at the deep-water, coarse-grained station (SFEI 1999). These concentrations of dissolved oxygen are well above the minimum ambient dissolved oxygen concentration of 5 mg/L established by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB 1995).

pH

The 1997 RMP measured pH at shallow water stations from 6.5 to 8.2. Deep-water, fine-grained stations had pH values ranging from 7.4 to 8.3, and the deep-water, coarse-grained station had pH values from 7.5 to 7.7 (SFEI 1999). These values represent typical concentrations found in seawater: 7.5 to 8.4 (Sverdrup et al. 1964). Because pH is affected by changes in temperature, salinity, alkalinity, and biological processes (i.e., photosynthesis, mineralization, and respiration), measurements of pH are expected to vary seasonally in San Francisco Bay.

Total Suspended Solids

The total suspended solids (TSS) levels in San Francisco Bay are highly variable depending on river and local stream sediment inflows and wind-wave resuspension at shallow-water depths. Total suspended solids in San Pablo Bay and Central Bay usually reach a maximum in late May and June when runoff is at its peak. Suspended solids increase again in late fall due to wind-wave resuspension (USACE and Contra Costa County1998).

During the January 1997 RMP sampling, the baywide mean of TSS was the highest recorded by the RMP, due to the big storm. For all three sampling periods in 1997, the RMP reported TSS ranging from 3 to 196 mg/L for the shallow/intertidal stations. The deep-water, fine-grained stations had TSS values ranging from 1 to 126 mg/L, and the deep-water, coarse-grained station had values ranging from 5 to 20 mg/L (SFEI 1999). These differences are generally correlated with proximity to areas of high runoff. The highest TSS values were observed at the shallow/intertidal stations in the northern reaches of the Bay during the January sampling, due to their proximity to areas of high runoff. Lower TSS values were observed for the deep-water, fine-grained stations, as these stations are generally located in the southern reaches of the Bay, in areas of lower runoff. The deep-water, coarse-grained station (Red Rock) had even lower TSS values.

Data collected by the USGS during water year 1998 show much higher TSS values than those collected by the RMP for 1997. The USGS data show TSS concentrations well above 1,000 mg/L during some periods of the year in both Central and South San Francisco Bay (Buchanan and Ruhl

2000). It should be noted, however, that the USGS TSS measurements were taken from mid-depth and near-bottom depths, whereas the RMP TSS measurements were taken from 1 meter below the water surface. As would be expected, TSS values generally increase with depth in the water column within San Francisco Bay.

Nutrients

Municipal and industrial input (i.e., local stream inflow and sewage input), freshwater inflow, and the Pacific Ocean are the primary sources of nutrients contributing to San Francisco Bay's nutrient levels. Mineralization and bottom sediments are secondary sources (USACE and Contra Costa County1998). Sewage effluents are the primary contributors of ammonia, nitrate+nitrite, and phosphate; the ocean and Delta outflow (i.e., the Sacramento and San Joaquin river delta) supply the majority of silicates (Conomos et al. 1985). Nutrient levels fluctuate with periods of increased and decreased biological productivity and urban discharges. Consequently, utilization of nutrients (i.e., photosynthesis) and nutrient availability vary spatially and seasonally within the Bay.

The highest nutrient levels measured at the shallow/intertidal stations during the 1997 RMP were phosphate at 700 µg/L, ammonia at 400 µg/L, nitrate at 4,100 µg/L, nitrite at 136 µg/L, and silicates at 800 µg/L. At the deep-water, fine-grained stations, the highest nutrient levels measured were phosphate at 330 µg/L, ammonia at 200 µg/L, nitrate at 900 µg/L, nitrite at 44 µg/L, and silicates at 600 µg/L. The highest nutrient levels measured at the deep-water, coarse-grained station were phosphate at 70 µg/L, ammonia at 100 µg/L, nitrate at 300 µg/L, nitrite at 13 µg/L, and silicates at 600 µg/L (SFEI 1999). The highest nutrient levels were observed at the shallow-water stations, and decreased from the deep-water, fine-grained stations to the deep-water, coarse-grained station (Red Rock). The higher nutrient levels observed at the shallow-water stations are likely due to the proximity of these stations to freshwater inflow.

Metals and Organic Chemicals

The Pollutant Policy Document (PPD), prepared by the SWRCB in 1990, identifies and characterizes pollutants of concern in the Bay, as well as the Sacramento-San Joaquin Delta Estuary. The pollutants of concern were identified based on their widespread occurrence or frequency of occurrence and their potential to cause adverse impacts on beneficial uses. These pollutants are arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, zinc, tributyltin (TBT), organochlorines, chlorinated dibenzodioxins and dibenzofurans, and hydrocarbons (particularly PAHs). Five sources have been identified in the PPD, including point sources, urban runoff, nonurban runoff, riverine sources, and others. Some contaminant levels are very site-specific based on local municipal and industrial discharges (SWRCB 1990). Concentrations of metals and organics in Bay water, where available, are provided in Table 4.2-2.

Similar to the nutrient levels, the highest metal and organic contaminant concentrations were observed at the shallow-water stations, and the concentrations decreased from the deep-water, fine-grained stations to the deep-water, coarse-grained station. The highest concentrations generally occurred at the shallow-water stations in the northern reach of the Bay during the January sampling period. These elevated concentrations coincided with the high TSS values observed in this area during the period of high flow, suggesting that the January flows transported higher contaminant concentrations than normal into the estuary. This water quality parameter appears to be more affected by spatial and seasonal patterns than by water depth.

Several metal and organic chemical concentrations were above water quality guidelines (WQGs) for the 1997 RMP water samples. One or more stations in the shallow/intertidal areas exceeded the WQGs for copper (dissolved), mercury, nickel, chromium, lead, zinc, total PCBs, Dieldrin, DDE, and DDT. One or more stations in the deep-water, fine-grained areas exceeded the WQGs for copper (dissolved), mercury, nickel, Dieldrin, and total PCBs. WQG exceedances were observed at the deep-water, coarse-grained station for Dieldrin and total PCBs (SFEI 1999). WQGs used in this comparison are from the proposed EPA California Toxics Rule (1997) 304(a) Criteria and the San Francisco Basin Plan (SFBRWQCB 1995), for those chemicals that have established WQGs.

Sediment Quality

Sediment quality in the Estuary varies greatly according to the physical characteristics of the sediment, proximity to historical waste discharges, the physical/chemical condition of the sediment, and sediment dynamics that vary with location and season (USACE et al. 1998). The 1997 RMP sediment monitoring provides reliable measurements of sediment contamination that reflect the most recently deposited sediments (SFEI 1999).

The 1997 RMP sediment monitoring measured several general characteristics of the sediment, including grain sizes, pH, total organic carbon (TOC), and concentrations of ammonia, hydrogen sulfide, and total sulfides. These data are presented in Table 4.2-3, organized by station type (shallow/intertidal, deep-water fine-grained, and deep-water coarse-grained).

The 1997 RMP sediment monitoring also measured contaminant concentrations. According to the 1997 RMP data, concentrations of most contaminants were higher in the Southern Sloughs and South Bay than in the other Estuary reaches. Average concentrations of chromium, cadmium, lead, mercury, nickel, selenium, zinc, and chlordanes were highest in sediments of the Southern Sloughs, PAHs were highest in the South Bay, and PCBs were highest in the Southern Sloughs and South Bay. In contrast, arsenic was highest in the Central Bay, and copper and total DDTs were highest in the Northern Estuary. Concentrations at the coarser-grained sediment sites were generally lower than at the finer-grained sites (SFEI 1999). Since there are no formal regulatory sediment contaminant guidelines for the San Francisco Bay, the RMP results for sediment monitoring were compared to several different sets of guidelines. Most of the 1997 RMP sediment samples had multiple guideline exceedances (SFEI 1999).

Sediment chemistry data gathered from several in-Bay studies were summarized by Long and Markel (1992). Data collected from the central basins of San Pablo Bay, Central Bay, and South Bay were compared with data collected in the peripheral areas (i.e., harbors, ship channels, marinas, and industrial waterways). Among the three basins, mean concentrations of contaminants were somewhat similar, and the peripheral harbors and channels had higher contaminant concentrations than the basins. According to Long and Markel (1992), the distribution of toxicity in the Bay is subject to small-scale patchiness.

4.2.3 Hydrodynamics

The San Francisco Bay estuary is a complex, dynamic water system composed of interconnected embayments, sloughs, marshes, and channels. The ocean, river and waters that mix in this system vary depending on location and season. In general, circulation is affected by tides entering the Bay, local winds, basin bathymetry, and the local salinity field (USGS 1984).

Table 4.2-3. 1997 RMP Sediment Quality Characteristics Data for the San Francisco Bay

	Shallow/Intertidal	*Deep Water Fine-*	*Deep Water Coarse-*

Parameter	Stations [1]	grained Stations [2]	grained Station [3]
Gravel+shell (average %)	1.0	2.7	4.0
Sand (average %)	23.5	33.9	69.5
Silt (average %)	28.5	21.3	6.5
Clay (average %)	46.8	42.2	20
pH	6.9-8.4	7.6-8.0	8.7
Total Organic Carbon (%)	0.1-1.8	0.5-1.4	0.1-0.6
Ammonia (mg/L)	ND-5.6	ND-3.3	0.3-0.7
Hydrogen sulfide (mg/L)	ND-0.1	0.01-0.07	ND-0.01
Total sulfides (mg/L)	0.1-0.6	0.1-0.6	ND-0.8

Notes:

1. RMP stations used to characterize shallow/intertidal areas included the following: BD41, BA10, BA41, BC11, BC32, BC21, BC41, BD22, BD31, BA21, BF21, and BF40.

2. RMP stations used to characterize deep-water, fine-grained areas included the following: BA30, BB15, BB30, BB70, and BF10.

3. The RMP station used to characterize deep-water, coarse-grained areas was BC60. Refer to the SFEI (1999) document for detailed descriptions of the RMP stations.

4. ND = not detected

Source: SFEI 1999.

Freshwater flows from the rivers and streams of the Sacramento and San Joaquin River system meet in a complex of island and channels (the Delta), then empty into the northeastern end of San Francisco Bay (Nichols and Pamatmat 1988). San Francisco Bay is comprised of a deeper central region near the City of San Francisco (Central Bay), and broad, lateral shoal regions to the north and south (Suisun, San Pablo, and South Bays). These shoal areas are incised by deep channels whose depths are maintained by river and tidal scouring. The average depth of San Francisco Bay is about –6.1 meters (-19 feet) at MLLW, while the median depth is about 2 meters (-6 feet) (Conomos et al. 1985).

Water circulation in the northern reach of San Francisco Bay is strongly influenced by the Delta outflows. This portion of the estuary system is classified as slightly to highly stratified. Freshwater discharging from the Delta moves as an upper layer of low density water toward the open ocean and a net subsurface flow of marine water flows toward the head of the estuary (i.e., Sacramento and San Joaquin rivers). The total flow into the estuary from the Delta represents about 90 percent of the annual river inflow to San Francisco Bay. All other rivers and streams entering the Bay are comparatively small, and most of these are intermittent with little or no flow during the summer months (Conomos et al. 1985).

The South Bay receives only minor amounts of freshwater inflow from the surrounding watershed, resulting in tidal lagoon characteristics with relatively constant salinity (Monroe et al. 1992). As in the estuary's northern reach, Delta outflow has a strong influence on the amount of time water resides in South Bay. When flows are low, it may take more than 3 months for South Bay water to move northward into Central Bay. Under high flow conditions, this exchange can occur in 2 or 3 weeks (Smith 1987).

Because San Francisco Bay is relatively shallow (averaging -6 meters MLLW), the tides are a significant component of water circulation and mixing within the Bay. Tides in San Francisco Bay are diurnal and semidiurnal (USGS 1984). The tidal range is greatest (2.6 meters) at the extremity of South Bay, decreasing to 1.7 meters at the Golden Gate (the Bay's narrow connection to the ocean), 1.3 meters at Suisun Bay, and to progressively narrower ranges in the northern reach. Such tidal ranges contribute to a tidal prism (the volume of water between low and high tide levels that passes in and out of the Bay during each tidal cycle) that is about 24% of the Bay's total volume (Conomos 1979; Conomos et al. 1985).

The large, rapid exchange of water with the ocean produces strong tidal currents in the narrow straits separating the major embayments, and in the narrow mid-bay channels. This focusing of currents prevents the deposition of fine-grained sediments and contributes to well-winnowed, coarse channel-bottom sediments in the central and northern embayments (USGS 1984). Deep-water areas (greater than -20 feet) with rocky or coarse grained sediments in the northern and central Bay are identified in Figure 3. Conversely, current velocities are lower over the lateral shoals in each embayment, permitting the deposition of fine sediments supplied by the rivers and resuspended by wind waves and tidal currents. Although lower in velocity, currents on the shoals follow the general direction of the intensive tidal currents in the deeper channels (USGS 1984). Currents in the northern reach show ebb dominance of the surface water and flood dominance of the bottom water (estuarine or gravitational circulation) (Conomos 1979). Nontidal current speeds, estimated by drifter movements, average 4 cm/sec for the landward-flowing density current and 5 cm/sec for the seaward-flowing surface current (Conomos and Peterson 1977).

Strong seasonal winds are also important in water circulation and mixing (Conomos et al. 1985). Prevailing west and northwest winds, reinforced by solar heating of air masses in inland California, are strongest during the summer. These winds generate complex Bay-wide water circulation patterns that are superimposed on tide and river induced circulation (Walters et al. 1985). In the northern reach, Bay waters during the summer are nearly isohaline (i.e., have similar salinity throughout) because of wind and tidal mixing (Conomos 1979).

4.2.4 Transportation and Navigation

San Francisco Bay is used heavily for vessel transportation and navigation, including large commercial traffic (cargo ships, tankers, tugs, and barges), Naval traffic, ferry service, and private vessel traffic. Navigation channels and shipping areas in San Francisco Bay are outlined in Figure 3. The Ports and Waterways Safety Act of 1972 authorized the U.S. Coast Guard to establish, operate, and maintain vessel traffic services for ports, harbors, and other waters subject to congested vessel traffic. As a result, in 1972 the U.S. Coast Guard established the Vessel Transportation Service (VTS) for San Francisco Bay and designated traffic lanes for inbound and outbound vessel traffic, specified separation zones between vessel traffic lanes, and set up rules to govern vessels entering and leaving port (USACE and Contra Costa County 1997). The VTS is located on Yerba Buena Island and controls marine traffic throughout San Francisco Bay. VTS San Francisco averages 250 vessel movements a day (USCG 1999).

In May 1995, federal regulations went into effect establishing Regulated Navigation Areas (RNA) within San Francisco Bay to conform to International Maritime Organization (IMO) traffic routing standards (USACE and Contra Costa County 1997). The RNAs were developed with input from the Harbor Safety Committee of the San Francisco Bay Region, to increase navigational safety by organizing traffic flow patterns; reduce meeting, crossing, and overtaking situations between large vessels in constricted channels; and limit vessel speed (USCG 1999). The seven established RNAs include the San Francisco Bay RNA, North Ship Channel RNA, San Pablo Strait Channel RNA, Pinole Shoal Channel RNA, Southern Pacific Railroad Bridge RNA, Southampton Shoal / Richmond Harbor RNA, and Oakland Harbor RNA. The RNAs apply to power driven vessels of 1,600 or more gross tons, or tugs with a tow of 1,600 or more gross tons. These large vessels must not exceed a speed of 15 knots through the water and must have their engines ready for immediate maneuvering.

Hazards to navigation in San Francisco Bay include bathymetric features (submerged rocks, shoals, islands), bridges and other structures, fog and inclement weather, tides and currents, and vessel traffic.

San Francisco Bay is relatively shallow, averaging –6 meters (-19 feet) MLLW and limits deep draft vessels to the relatively narrow, main navigation channels. Submerged rocks and shoals are present around Alcatraz, Angel Island, Treasure Island, Yerba Buena Island, the Brothers Islands, and Red and Castro Rocks. Outside of the main navigation channels, lateral shoals are too shallow for deep draft vessels (see Figure 3).

A significant hazard to vessel navigation in San Francisco Bay is congestion due to other vessel traffic. Large commercial and Naval vessels are required by U.S. Coast Guard regulation to coordinate their movements by contacting the VTS and using designated traffic lanes when traveling in inland waterways. In October 1994, federal regulations made VTS participation mandatory (1) for power-driven vessels 40+ meters long while navigating, (2) when towing vessels 8+ meters long while towing, and (3) for vessels certified to carry 50+ passengers for hire while engaged in trade (USCG 1999). However, smaller commercial vessels (tugboats, ferryboats, and private vessels) often do not navigate within specific traffic lanes, but rather travel in the most direct route. These vessels can pose hazards to navigation, particularly if other circumstances such as fog are present. Although some small and private vessels are not required to coordinate their movements by contacting the VTS, the U.S. Coast Guard monitors all commercial, U.S. Navy, and private marine traffic within San Francisco Bay and local coastal waters. Typical vessel traffic routes, including ferries, in the San Francisco Bay are shown in Figure 9.

California has enacted regulations requiring all tank vessels (tankers and tank barges) carrying more than 5,000 tons of oil or petroleum product to be escorted by one or more escort vessels. These regulations are effective in the San Francisco Bay and Bay entrance, San Pablo and Suisun bays, and the lower parts of the Sacramento and San Joaquin rivers. This includes the entire length of Carquinez Strait, as well as passage under the Carquinez bridge complex (USACE and Contra Costa County 1997).

4.2.5 Air Quality

All activities associated with potential actions proposed under the Bay Plan Amendment would occur within the San Francisco Bay Area Air Basin (SFBAAB). The SFBAAB is composed of the counties of Santa Clara, San Mateo, San Francisco, Marin, Napa, Contra Costa, and Alameda, along with the southeast portion of Sonoma and the southwest portion of Solano counties. The SFBAAB covers an area of approximately 5,540 square miles. The boundary of the SFBAAB is shown in

Figure 10. Air quality in the immediate project areas and surrounding regional environment of the SFBAAB would be affected by emissions from sources associated with the proposed construction activities required to create the new habitats. These sources would primarily consist of the various types of dredging, hauling, and distribution equipment used to remove, transport, and place material.

Description of Resource

Air quality at a given location can be described by the concentrations of various pollutants in the atmosphere. Units of concentration are generally expressed in parts per million (ppm) or micrograms per cubic meter (µg/m^3). The significance of a pollutant concentration is determined by comparing the concentration to an appropriate federal and/or state ambient air quality standard. The standards represent the allowable atmospheric concentrations at which the public health and welfare are protected and include a reasonable margin of safety to protect the more sensitive receptors in the population. Federal standards, established by the EPA, are termed the National Ambient Air Quality Standards (NAAQS). The NAAQS for all averaging periods other than annual are defined as the maximum acceptable concentrations that may not be exceeded more than once per year. The annual NAAQS may never be exceeded. The state standards, established by the California Air Resources Board (ARB), are termed the California Ambient Air Quality Standards (CAAQS). The CAAQS are defined as the maximum acceptable pollutant concentrations that are not to be equaled or exceeded, depending on the specific pollutant. The NAAQS and CAAQS are presented in Table 4.2-4.

The state and federal standards have been adopted by the Bay Area Air Quality Management District (BAAQMD) for assessing local air quality impacts. The main pollutants of concern that are considered by the BAAQMD in their analysis include ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), reactive organic gases (ROG), oxides of nitrogen (N0x), particulate matter smaller than 10 microns in diameter (PM_{10}), and particulate matter smaller than 2.5 microns in diameter ($PM_{2.5}$). The BAAQMD focuses on these pollutants, as the project region presently does not attain or is in maintenance of the national and/or state ambient air quality standards for O_3, CO, and PM_{10}. New standards for $PM_{2.5}$ have been recently proposed, but not yet formally adopted.

Table 4.2-4. National and California Ambient Air Quality Standards

Pollutant	*Averaging Time*	*California Standards* [a]	*National Standards* [b]	
			Primary [c]	*Secondary* [d]
Ozone (O_3)	1-Hour	0.09 ppm (180 µg/m^3)	0.12 ppm (235 µg/m^3)	Same as Primary Standard
	8-Hour	—	0.08 ppm (160 µg/m^3)	Same as Primary Standard
Carbon Monoxide (CO)	8-Hour	9 ppm (10 mg/m^3)	9 ppm (10 mg/m^3)	—
	1-Hour	20 ppm (23 mg/m^3)	35 ppm (40 mg/m^3)	—
Nitrogen Dioxide (NO_2)	Annual	-	0.053 ppm (100 µg/m^3)	Same as Primary Standard
	1-Hour	0.25 ppm (470 µg/m^3)	-	—

Sulfur Dioxide (SO_2)	Annual	-	0.03 ppm (80 µg/m^3)	—
	24-Hour	0.04 ppm (105 µg/m^3)	0.14 ppm (365 µg/m^3)	—
	3-Hour	—	–	0.5 ppm (1,300 µg/m^3)
	1-Hour	0.25 ppm (655 µg/m^3)	—	—
Suspended Particulate Matter (PM_{10})	Annual (geometric)	30 µg/m^3	—	—
	Annual (arithmetic)	—	50 µg/m^3	Same as Primary Standard
	24-Hour	50 µg/m^3	150 µg/m^3	Same as Primary Standard
Suspended Particulate Matter ($PM_{2.5}$) [(e)]	Annual (arithmetic)	—	15 µg/m^3	Same as Primary Standard
	24-Hour	—	65 µg/m^3	Same as Primary Standard

Notes:

a. California standards for O_3, CO, SO_2 (1-hour and 24-hour), NO_2, PM_{10}, and visibility reducing particles are not to be exceeded. The standards for sulfates, lead, hydrogen sulfide, and vinyl chloride are not to be equaled or exceeded.

b. National standards other than 1-hour O_3, 8-hour O_3, 24-hour PM_{10}, 24-hour $PM_{2.5}$, and those based on annual averages, are not to be exceeded more than once a year. The 1-hour O_3 standard is attained when the expected number of days per calendar year with a maximum hourly average concentrations above the standard is equal to or less than one. The 8-hour O_3 standard is attained when the 3-year average of the annual 4th-highest daily maximum 8-hour concentrations is below 0.08 ppm. The 24-hour PM_{10} standard is attained when the 3-year average of the 99th percentile 24-hour concentrations is below 150 µg/m^3. The 24-hour $PM_{2.5}$ standard is attained when the 3-year average of the 98th percentile 24-hour concentrations is below 65 µg/m^3.

c. National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health.

d. National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects from a pollutant.

e. Standards for $PM_{2.5}$ have been proposed, but not yet adopted.

Although there are no ambient standards for ROG or NOx, they are important as precursors to O_3 formation.

Region of Influence

Identifying the region of influence (ROI) for air quality requires knowledge of the types of pollutants being emitted, the emission rates and release parameters of the pollutant source (e.g., release temperature, area of release, release height), the proximity of the source to other pollutant sources, and local and regional meteorological conditions. The ROI for emissions of inert pollutants (all pollutants other than O_3 and its precursors) is generally limited to a few miles downwind from a source. Thus, for the emission of inert pollutants from project-related activities, the ROI is limited to the immediate waters, waterways, and coastal areas of the San Francisco Bay and adjoining BCDC-jurisdictional water areas where dredging, material transport and placement activity would take place. (It is assumed for purposes of this plan amendment that no dredging, transport or placement activities would occur at inland locations, i.e., all activities would occur on, or adjacent to, BCDC-jurisdictional waters.)

The ROI for O_3 can extend much farther downwind than for inert pollutants. Ozone is a secondary pollutant formed in the atmosphere by photochemical reactions of previously emitted pollutants called "precursors." Ozone precursors are mainly the ROG portion of volatile organic compounds

(VOC) and NOx. In the presence of solar radiation, the maximum effect of ROG and NOx emissions on O_3 levels usually occurs several hours after they are emitted and many miles from the source. Ozone and O_3 precursors transported from other regions can also combine with local emissions to increase local O_3 concentrations. Therefore, the ROI for O_3 may include much of the SFBAAB.

Climate and Meteorology

The climate of the project area is classified as Mediterranean, characterized by cool, dry summers and mild, wet winters. The major influence on the regional climate is the Eastern Pacific High, a strong persistent anticyclone. Seasonal variations in the position and strength of this system are a key factor in producing weather changes in the area.

The proximity of the Eastern Pacific High and a thermal low pressure system in the Central Valley region to the east produces air flow generally from the west to northwest along the central and northern California coast for most of the year. The persistence of these breezes is a major factor in minimizing air quality impacts from almost 6 million people that live in the region. As this flow is channeled through the Golden Gate Bridge, it branches off to the northeast and southeast, once inside the Bay. As a result, winds often blow from the southwest in the Berkeley area and from the northwest in the South Bay. Easterly winds that blow toward the offshore waters also occur, but are mainly nocturnal and wintertime land breezes. These land breezes may extend many miles offshore during the colder months of the year until daytime heating reverses the flow back onshore.

During the fall and winter months, the Eastern Pacific High can combine with high pressure over the interior regions of the western United States to produce extended periods of light winds and low-level temperature inversions. This condition frequently produces poor atmospheric dispersion that results in degraded regional air quality. Ozone standards traditionally are exceeded when this condition occurs during the warmer months of the year.

Regulatory Setting

Air quality regulations were first promulgated with the Federal Clean Air Act of 1969 (CAA). This act established the NAAQS and delegated the enforcement of air pollution control regulations to the states. In California, the ARB is responsible for enforcing air pollution regulations, but they have delegated the responsibility of regulating stationary emission sources to local air agencies. In the SFBAAB, the BAAQMD is responsible for regulating stationary sources of air emissions. The following is a summary of the federal, state, and local air quality rules and regulations that apply to the proposed action.

Federal Statutes and Regulations

In areas that exceed the NAAQS, the CAA requires preparation of a State Implementation Plan (SIP), detailing how the state will attain the standards within mandated time frames. The Clean Air Act Amendments of 1990 (1990 CAA) revised the attainment planning process. The 1990 CAA identifies new emission reduction goals and compliance dates based upon the severity of the ambient air quality standard violation within a region.

The 1990 CAA states that a federal agency cannot support an activity unless the agency determines that the activity will conform to the most recent EPA-approved SIP within the region of the proposed action. This means that federally supported or funded activities will not (1) cause or contribute to any new air quality standard violation, (2) increase the frequency or severity of any existing standard violation, or (3) delay the timely attainment of any standard, interim emission reduction, or other milestone. The EPA provides no classification on the severity of the O_3 nonattainment condition in the SFBAAB. However, for purposes of determining project conformity, it is assumed that the region has a moderate nonattainment status for O_3. Consequently, construction activities would conform to the most recent EPA-approved SIP if the annual emissions remain less than 50 tons of VOC or 100 tons of NOx or CO.

State Regulations

The California Clean Air Act of 1988, as amended in 1992 (CCAA), outlines a program to attain the CAAQS for O_3, NO_2, SO_2, and CO by the earliest practical date. Since the CAAQS are more stringent than the NAAQS, emissions reductions beyond what would be required to show attainment for the NAAQS will be needed. Consequently, the main focus of attainment planning in California has shifted from the federal to state requirements. Similar to the federal system, the state requirements and compliance dates are based upon the severity of the ambient air quality standard violation within a region.

Local Statutes and Regulations

The BAAQMD is responsible for attaining and maintaining the state and national ambient air quality standards within the SFBAAB. The BAAQMD uses the *1997 Clean Air Plan* (*1997 CAP*) to address attainment of the state O_3 standard. Due to the inability of the SFBAAB to attain the national O_3 standard, the BAAQMD has developed the *San Francisco Bay Area Ozone Attainment Plan* (*O_3 Attainment Plan*) (BAAQMD 1999). This plan provided measures that will reduce O_3 precursor emissions and bring the region into attainment of the 1-hour national O_3 standard within the next few years. The *O_3 Attainment Plan* has been approved by the ARB and is presently being reviewed by the EPA.

Emission control measures developed from the CAP and the Ozone Attainment Plan are eventually adopted into the *BAAQMD Rules and Regulations* (BAAQMD 2000). The *Rules and Regulations* establish emission limitations and control requirements for stationary sources, based upon their source type and magnitude of emissions. For example, stationary emission sources associated with the proposed action could be subject to the Authority to Construct (ATC)/Permit to Operate (PTO) requirements of BAAQMD Regulation 2. This regulation outlines thresholds that trigger requirements for (1) best available control technologies (BACT), (2) dispersion modeling analyses, (3) emission offsets, and (4) ambient pollutant monitoring.

Baseline Air Quality

The EPA designates all areas of the United States as having air quality better than (attainment) or worse than (nonattainment) the NAAQS. A nonattainment designation means that a primary NAAQS has been exceeded more than three discontinuous times in 3 years in a given area. Pollutants in an area are often designated as unclassified when there is a lack of data for the EPA to form a basis of attainment status. The SFBAAB is currently in nonattainment of the federal standard for O_3, attainment of the federal standards for NO_2 and SO_2, is a maintenance area for CO (urbanized areas only), and is unclassified for PM_{10} (ARB 2000).

The ARB designates areas of the state as either in attainment or nonattainment of the CAAQS. An area is in nonattainment if the CAAQS has been exceeded more than once in 3 years. At the present time, the SFBAAB is in nonattainment of the CAAQS for O_3 and PM_{10} and in attainment of the CAAQS for CO, NO_2, and SO_2 (ARB 2000).

Concentrations of photochemical smog, or O_3, are highest during the warmer months and coincide with the season of maximum insolation. Inert pollutant concentrations (pollutants other than O_3) tend to be the greatest during the cooler months when extended periods of light wind conditions and surface-based temperature inversions occur. The following is a discussion of the various pollutants monitored within the SFBAAB.

Ozone

Ozone is a colorless gas that is formed in the atmosphere by the photochemical reactions of ROG and NOx. It is a respiratory irritant and can cause damage to lung tissue. Sensitive plant species and synthetic materials can also be damaged by O_3 at concentrations as low as 0.02 ppm.

Nitrogen Dioxide

Nitrogen dioxide is a reddish-brown gas with an irritating odor. As a product of nitrogen oxides (NOx), NO_2 is one of the primary pollutants in the formation of photochemical smog. Nearly all NO_2 is emitted from manmade sources such as automobiles and power plants that burn fossil fuels. Health effects associated with NO_2 range from irritation to the eyes, nose, and throat to increased susceptibility to infection.

Carbon Monoxide

Carbon monoxide is a clear, odorless gas produced by the incomplete combustion of fossil fuels and organic substances. The natural degradation of plant matter can also contribute to the production of CO, but motor vehicles are by far the largest man-made source. The highest ambient CO concentrations usually occur near congested transportation arteries and intersections. Carbon monoxide is not a respiratory irritant, but rather passes through lungs and interferes with the transfer of oxygen in blood. Symptoms of exposure include dizziness, headache, and, in extreme cases, loss of consciousness.

PM_{10} and $PM_{2.5}$

PM_{10} and $PM_{2.5}$ are produced by a wide range of activities, including natural wind erosion of soil, combustion of fossil fuels, mining, and transporting and handling of minerals. PM_{10} and $PM_{2.5}$ are of concern because the small particles can pass through the bronchial passages in the lung and into the alveoli where they can be retained indefinitely. If PM_{10} or $PM_{2.5}$ contain water-soluble compounds; the soluble portion can be absorbed and transported through the blood system to other organs where they can cause damage.

Sulfur Dioxide

Sulfur dioxide is a colorless, nonflammable gas with a pungent odor. SO_2 is a respiratory irritant that is mainly produced from the combustion of sulfur-containing fossil fuels, as a byproduct in the refining of fossil fuels from crude oil, and from the production of sulfuric acid. Marine vessels contribute substantially to SO_2 emissions in the SFBAAB (approximately 15 percent of the total from all sources) due to the use of high-sulfur fuels. About one-third of these emissions occur when vessels operate in harbors and bays and two-thirds occur while vessels cruise along the coast (ARB 1984).

San Francisco Bay Area Air Basin Emissions

Table 4.2-5 displays the air emissions that occurred within the SFBAAB in 1996 (ARB 2000). Mobile sources are one of the largest contributors to air pollutants in the SFBAAB. Mobile sources account for approximately 57 percent of the ROG, 89 percent of the CO, 78 percent of the NOx, 21 percent of the SO_2, and 9 percent of the PM_{10} emitted in the SFBAAB.

4.2.6 Land/Water Use

The ROI for purposes of land and water use analysis is defined as those locations in San Francisco Bay of 20-foot or greater depth and the nearby land and water areas. This description addresses existing land and water uses in the ROI, including recreational uses such as boating and fishing.

Navigational issues and commercial boating (including tankers, freighters, and passenger ferries) are addressed under Transportation and Navigation (section 4.2.4).

San Francisco Bay is a natural bay encompassing 548 square miles of inland waterways on the northern California coast. The Bay Area comprises a nine-county area in northern California that includes the counties of Alameda, Contra Costa, Solano, Napa, Sonoma, Marin, San Francisco, San Mateo, and Santa Clara (see Figure 10). The Bay Area is one of the major shipping and port centers on the West Coast. The primary commercial shipping ports in the Bay are the ports of Oakland, Richmond, and San Francisco.

San Francisco Bay is divided into three sections. The Central Bay is bounded by the Richmond-San Raphael Bridge on the north, the Oakland Bay Bridge on the south, and the Golden Gate Bridge on the west (see Figure 5). The portion south of the Oakland Bay Bridge is often referred to as the South Bay (Figure 4). The portion north of the Richmond-San Raphael Bridge is known as San Pablo Bay (Figure 6).

The central portion, which is the busiest part of the Bay, includes the ports of San Francisco and Richmond and many small boat harbors and marinas. Public access points in this portion of the Bay include Berkeley Marina in Berkeley, Clipper Yacht Harbor in Sausalito, Emeryville Marina in Emeryville, and Richmond Marina Bay Harbor in Richmond. Despite strong currents, high winds, fog, and heavy shipping traffic, recreational use in the central portion of the Bay is very high. Recreational sailing, fishing, and sea kayaking are common throughout this portion of the Bay, including in the shipping channels. Water skiing, jet skiing, and windsurfing are popular in some of the more sheltered areas.

Table 4.2-5. 1996 Estimated Annual Average Emissions for the San Francisco Bay Area Air Basin (tons/day)

Source Type/Category	*ROG*	*CO*	*NOx*	*SOx*	*PM_{10}*
STATIONARY SOURCES					
Fuel Combustion	3	32	92	10	4
Waste Disposal	5	0	0	0	0
Cleaning and Surface Coating	53	0	0	--	0

Petroleum Production and Marketing	47	1	8	35	1
Industrial Processes	12	25	3	7	12
Subtotal	**120**	**58**	**100**	**53**	**17**
AREA-WIDE SOURCES					
Solvent Evaporation	76	--	--	--	--
Miscellaneous Processes	23	260	21	1	130
Subtotal	**99**	**260**	**21**	**1**	**130**
MOBILE SOURCES					
On-Road Motor Vehicles	250	2,300	300	4	8
Other Mobile Sources	40	460	120	10	7
Subtotal	**290**	**2,760**	**420**	**14**	**15**
Total for the Air Basin	**510**	**3,100**	**540**	**68**	**160**
Source: California Air Resources Board. Http://www.arb.ca.gov/emisinv/maps/basins/absfmap.htm.					

South Bay includes the Port of Oakland and many small boat harbors and marinas. Major public access points in the South Bay include Oyster Point Marina in South San Francisco, Coyote Point Marina in San Mateo, Port of Redwood City in Redwood City, Mulford Landing in San Leandro, Ballena Isle Marina in Alameda, and Grand Street Public Ramp in Alameda. Despite the vast expanse of water and numerous access points, the South Bay has relatively light recreational use (Stienstra 1996). Most of the sailing and boating activity that originates in South Bay is oriented north to the central portion of San Francisco Bay.

San Pablo Bay extends from the Richmond–San Raphael Bridge to the Carquinez Bridge (Figure 7). Recreation on San Pablo Bay is primarily limited to fishing and nature watching (Stienstra 1996). East of Carquinez Bridge is a series of smaller bays with several small boat harbors and marinas, numerous islands, and the confluence of the Sacramento and San Joaquin rivers.

Land uses on the Bay include several islands, most notably Angel, Alcatraz, Treasure, and Yerba Buena islands, all in the central portion of San Francisco Bay. Angel Island, which at 740 acres is the largest island in the Bay, is part of the California State Park system. Alcatraz Island, an exceptionally popular tourist attraction, is part of the Golden Gate National Recreation Area. Yerba Buena Island, located at the middle of the Oakland Bay Bridge, is owned and managed by the U.S. Coast Guard. Treasure Island is a manmade island owned by the U.S. Navy. Access to Yerba Buena and Treasure islands is limited to authorized users only.

4.2.7 Noise

The ROI for noise effects are the land and water areas adjacent to potential beneficial reuse sites. The beneficial reuse sites are all located in portions of San Francisco Bay with a water depth of 20 feet or greater. Existing noise sources, sensitive receptors in the ROIs, and the planning framework for noise are described in the following paragraphs. Wildlife may also be sensitive to increased noise levels; potential noise impacts on wildlife are addressed under biological resources in section 6.2.

Noise Descriptors

Noise is defined as unwanted sound that disrupts normal activities or that diminishes the quality of the environment. Noise is usually caused by human activity and is added to the natural acoustic setting of a locale. Land uses such as housing, religious, educational, convalescent, medical facilities, and passive recreational sites are generally more sensitive to increased noise levels than are commercial or industrial land uses. Noise sensitive land uses are referred to as sensitive receptors.

Noise is customarily measured in decibels (dB), units related to the apparent loudness of sound. An A-weighted decibel (dBA) represents sound frequencies normally heard by the human ear. On this scale, the normal range of human hearing extends from about 3 dBA to 140 dBA, with speech normally occurring between 60 dBA and 65 dBA. A 10-dBA increase in the level of a continuous noise represents a perceived doubling of loudness, whereas a 3-dBA increase is just noticeable to most people.

Noise levels attenuate (lessen) at greater distance from the source. When noise propagation is unhindered, the noise level drops by 6 dB for every doubling of the distance over land and by 5 dB for every doubling of the distance over water. Intervening topography further diminishes noise levels and, depending on the height and extent of the topography, it can totally block noise propagation.

Environmental noise levels fluctuate over time, thus, a time-averaged noise level in dBA is often used to characterize the acoustic environment at a given location. The average noise intensity over a given time is the energy equivalent noise level (L_{eq}). The day-night equivalent noise level (Ldn) is a 24-hour L_{eq}, which is derived by adding a 10 dBA "penalty" to noise levels measured between 10 P.M. and 7 A.M. The community noise equivalent level (CNEL) incorporates an additional 5-dBA penalty to sound levels measured between 7 P.M. and 10 P.M. These "penalties" account for the greater sensitivity of people to high noise levels at night. Noise levels of different activities and the human response criteria for those noise levels are presented in Table 4.2-6.

Human response to noise varies from individual to individual and depends on the ambient environment in which the noise is perceived. The same noise that would be highly intrusive to a sleeping person or someone in a quiet park might be barely perceptible at an athletic event or in the middle of the freeway at rush hour. Therefore, planning for an acceptable noise exposure must take into account the types of activities and corresponding noise sensitivity in a specified location for each particular set of land uses. Some general guidelines are as follows: sleep disturbance may occur at less than 50 dB, interference with human speech begins at around 60 dB, and hearing damage may result from prolonged exposure to noise levels in excess of 90 dB.

Existing Noise Environment

Throughout much of the ROI, natural sounds of wind, waves, and birds dominate the ambient noise levels. Measured noise levels for the ROI are not available, but in any particular location, natural ambient noise levels vary considerably depending on the weather. Generally, however, the natural ambient noise could be characterized as peaceful.

Noise sources that contribute to ambient noise levels in the ROI are typically transportation-related (mobile) sources, including vehicular traffic on the bridges, ship traffic, and aircraft overflights. Some onshore point noise sources may contribute to local ambient noise levels where the ROI is close to the shore, for example along the City of San Francisco shoreline and some portions of the City of Oakland (see Figure 3). Typical point sources might include construction sites, industrial sites, or other places where heavy equipment or noise-generating machinery is used.

When the weather is calm and the natural ambient noise level is low, both mobile and stationary noise sources can be heard for long distances across the water. When the wind is blowing and the water's surface is rough, however, even relatively loud nearby noise sources can be completely masked.

Table 4.2-6. Typical Sound Levels Measured in the Environment

Sound (Distance from Sound Source)	*A-Weighted Sound Level (in Decibels)*	*Noise Environments*	*Subjective Impression*
	140		
Civil defense siren (100’)			
	130		
Jet takeoff (200’)	120		Pain threshold
	110	Rock music concert	
Pile driver (50’)	100		Very loud
Ambulance siren (100’)			
	90	Boiler room	
Freight cars (50’)		Printing press plant	
Pneumatic drill (50’)	80	Kitchen garbage disposal	
	70		Moderately loud
Vacuum cleaner (10’)	60	Data processing center	
		Department store	
Light traffic (100’)	50	Private business office	
Large transformer (200’)			
	40		Quiet
Soft whisper (5’)	30	Quiet bedroom	
	20	Recording studio	
	10		Threshold of hearing
	0		

Source: U.S. Department of Housing and Urban Development 1985.

5.0 RISKS AND BENEFITS OF HABITAT ENHANCEMENT USING DREDGED MATERIAL

The principal purpose of this document is to evaluate, on a programmatic level, the potential environmental impacts of using dredged material for habitat enhancement in San Francisco Bay. The short-term impacts (described in Chapter 6) of this practice derive principally from construction of the enhancement projects (dredged material placement, etc.). These impacts are mostly adverse (water quality, etc.), but they are usually temporary. In the long-term, habitat enhancement projects are intended to result in a net benefit to habitat functions and values, a beneficial impact. Of course, a habitat enhancement project will result in the loss (or at least major modification) of the existing habitat and community at the project site. The purpose of a proposed enhancement is to establish habitat at a site that has significantly greater ecological value than the site's existing habitat. For each proposed enhancement project, a detailed analysis of the habitat and community losses and gains that would result from the project should be conducted. The project should proceed only if this analysis shows a significant net biological benefit according to agreed-upon criteria. Project review should also take into account the potential for other types of long-term impacts, such as adverse effects on circulation, flushing, and water quality. Habitat projects should be designed and implemented to avoid such impacts. However, habitat alteration projects sometimes result in unforeseen effects (see section 3.4). The review of specific proposed habitat enhancement projects needs to consider the possibility of such effects.

Another factor that must be taken into account in reviewing proposed enhancement projects is the risk of project failure. This includes failure of either the physical or biological aspects of a project, or both. Physical failures involves a failure to achieve the intended physical features of the project, such as elevation, slope, grain size, or maintaining the placed material at the intended location. An example would be placing fine-grained material at a site where water currents were stronger than expected, resulting in transport off-site of some or all of the placed material. Another example would be structural failure of a containment berm, resulting in down-slope slumping of placed material. Biological failure means failure to achieve the biological objectives of a project, in terms of species that become established at the site, or the density or rate at which desired species become established.

Physical failure frequently leads to biological failure, because the physical requirements of the desired species are not achieved. Biological failure can sometimes contribute to physical failure, such as slow establishment of vegetation leading to erosion of placed material. Many past habitat enhancement projects have resulted in at least partial biological failure, as described in section 3.4. However, partial biological failure does not necessarily mean that a project has failed in the final analysis. Even with partial failure, a habitat enhancement project may still represent a significant ecological benefit over pre-existing conditions. Many enhancement projects take into account the potential for partial biological failure, and so are designed to result in significant benefits even if not all project objectives are met.

Full or partial failure of a habitat enhancement project can have adverse environmental impacts. For example, if all of the intended biological benefits are not achieved, the ecological value of the enhanced habitat may actually be less than that of the displaced habitat, resulting in a net loss of ecological value. If dredged material cannot be maintained at a placement site, then high TSS and related adverse water quality impacts could occur in adjacent areas. Even if a project is carefully designed and built, it may have unforeseen hydrodynamic effects, with resulting adverse impacts on water quality and biota. Chapter 6 describes the types of adverse environmental impacts that could result from full or partial failure of habitat enhancement projects.

The likelihood of physical and/or biological success (including achievement of a net biological benefit) of a habitat enhancement project depends on several factors. Key among these are the type of habitat to be created/enhanced and the environmental characteristics of the proposed project site, including existing habitat at the site. Some existing habitats are physically unsuitable for creating certain types of habitats, because the required dredged material cannot be maintained at the site due to slope or current conditions. Physical suitability is also important to the biological success of a habitat project. Whether a particular habitat project will result in a net biological benefit depends in part on the value of the existing habitat at the proposed project site, which would be lost as a result of the project.

Table 5-1 shows the general feasibility of enhancing/creating various habitat types in the identified existing habitats in San Francisco Bay. This assessment includes the feasibility of achieving the physical features of each habitat type, as well as the likelihood of achieving a net biological benefit, considering the value of both the existing and created/enhanced habitats. The potential for at least partial failure of the enhancement project must also be considered. This analysis is necessarily programmatic and general. Although an existing habitat type may be considered generally suitable for enhancement or creation of a particular new type of habitat, there will be many sites for which this is not true, because of site-specific conditions. These issues would be addressed as part of the CEQA and permitting/approval process for any specific proposed habitat project.

As shown in Table 5-1, deep-water, rocky bottom habitat is probably not physically suitable for creating any of the various habitat types, because these rocky areas are characterized by strong currents that would make it impossible to maintain deposited dredged material at a placement site. In addition, these deep rocky areas are located near the mouth of the Bay, Angel Island, and in the navigation channel at Point San Pablo, which would be unsuitable for conversion to shallow-water habitat for navigation reasons. Similarly, moderately strong currents present in deep-water, coarse-grained sediment areas would make it difficult to maintain habitats (eelgrass, mud/sand flats, and salt marsh) with fine-grained sediments. However, it may be possible to maintain habitats with coarser sediments (for example, unvegetated shallow subtidal habitat on sand or cobbles, and bird use islands) in these areas. If either of these habitat types could be physically maintained in these areas, the feasibility of the projects would depend on assuring biological benefits, which would depend on the relative values of the lost and created habitats as well as the risk of failure. These factors would have to be evaluated on a case-by-case basis; feasibility is not certain.

The situation is similar for enhancing existing shallow habitats, and for creating unvegetated shallow habitat or bird islands in existing deep-water, fine-grained areas. In these cases, water currents would generally be weak enough to maintain both coarse and fine sediments, particularly if berms or other structures were built to help contain the placed material. The biological benefits for these cases are less certain than physical suitability, however. This is especially true for enhancing existing shallow habitats. These habitats generally have high ecological value, so the benefit of converting to another type of habitat (shallow subtidal or intertidal) is less clear, particularly considering the potential for full or partial failure of the enhancement project.

Existing tidal marsh is generally infeasible for enhancement. The intertidal elevations at which tidal marsh occurs are too high to support eelgrass, unvegetated shallow habitat, and bird islands (assuming these islands must be surrounded by water even at low tide). Converting tidal marsh to mud or sand flats is unlikely to result in an ecological benefit. Tidal marsh and salt marsh are essentially the same habitat (in areas of high salinity), and it is not feasible to change salinity at a site to the extent that brackish marsh could be converted to salt marsh. In any case, achieving a net ecological benefit from such a conversion is unlikely.

Overall feasibility is generally better for creating eelgrass, intertidal mud/sand flats, and salt marsh in deep-water, fine-grained areas. These areas tend to have weak currents, so that they are generally physically suitable for maintaining placed dredged material. The biological values of these three types of created habitats are high enough that there is a reasonable likelihood of achieving a net biological benefit by converting from deep-water habitat. Nevertheless, the potential for full or partial project failure would have to be considered in the analysis of each project.

Dredged areas are generally physically suitable for maintaining project features constructed from dredged material. In some dredged areas, however, strong currents may erode and sweep away fine-grained material. In addition to currents, wind and waves, particularly during storms, may make it difficult to maintain shallow-water habitat in open, unprotected areas of the Bay. The biological value of the habitats and communities of dredged areas is generally low enough that there is a good likelihood of achieving a significant biological benefit by converting to one of the types of created habitats considered in the present analysis. Physically and biologically, therefore, converting dredged areas to other types of habitats (particularly shallower habitats) represents some of the most feasible types of habitat conversions under consideration. Again, this would have to be determined through a detailed analysis of each proposed enhancement project.

The need to maintain navigation uses would obviously be a constraint to creating or enhancing shallow habitat in some of the existing habitat types. For example, shallow habitat would obviously not be suitable for active navigation channels and berths (maintained deep areas), because of conflicts with navigation. Creating shallow habitat in many open parts of the Bay (not just recognized navigation channels) may also create conflicts with navigation. Dredged areas that are no longer needed for navigation, such as those adjacent to closed military bases, may be suitable for habitat creation or enhancement, depending on environmental conditions at the particular site. However, areas that have not been dredged for a prolonged period of time may have reestablished stable biological communities. This will need to be addressed on a project-specific basis.

Table 5-1. Relative Feasibility of Enhancing Existing Habitats

Existing Habitat Types	CREATED / ENHANCED HABITAT TYPES				
	Eelgrass	*Unvegetated Shallow Subtidal*	*Intertidal Mud/Sand Flats*	*Salt Marsh*	*Islands for Bird Use (Nesting or Roosting Islands)*
Deep Water, Rocky Bottom	I	I	I	I	I
Deep Water, Coarse-grained Sediment	I	P	I	I	P
Deep Water, Fine-grained Sediment	F	F	F	F	F
Shallow Water	P	P	P	P	P
Dredged Areas*	P**	F	F	F	F
Tidal Marsh	I	I	P	I	I

Notes:
- F = Generally feasible: physically suitable; good potential for net biological benefits.
- I = Generally infeasible, primarily for physical reasons.
- P = Potentially feasible: physically suitable; potential for biological benefits is case-specific.

* Only inactive dredged areas would be suitable for creation / enhancement of shallow-water habitat.

** Most dredged channels cut through areas of high turbidity and shallow mudflats; these areas are poor candidates for eelgrass. The Port of Oakland's Middle Harbor area would be the exception rather than the rule. For this reason, a "P" is placed here.

6.0 IMPACTS OF CREATING/ENHANCING HABITAT

Because of the programmatic, planning-level analysis in this document, the impact analysis below is necessarily presented in general terms. Also, for many resource areas, the impacts would not vary substantially by the type of created / enhanced shallow-water habitat. Where impacts could vary by the type of created / enhanced habitat, this is discussed.

6.1 BIOLOGICAL RESOURCES

This section describes the general impacts on biological resources expected to result from converting existing deep-water habitats in San Francisco Bay to shallow-water habitat, and from converting one type of shallow habitat to another. An impact discussion specific to the five types of created / enhanced habitat analyzed for this Amendment follows this general discussion (see sections 6.1.1 through 6.1.5).

This section discusses the impacts of placing dredged material at sites in San Francisco Bay to create new shallow-water habitats, as well as changing the substrate and other existing characteristics of a site. Impacts are described for plankton, aquatic plants, benthic invertebrates, fish, marine mammals and birds, and threatened and endangered species. There may be temporary adverse impacts from placing dredged material to create or enhance shallow habitat. With proper project design and implementation, these impacts will typically be insignificant. Since the goal of these projects will be to enhance habitat, each project would be supported by a detailed environmental review that indicates a significant net biological benefit. If this is not the conclusion of the environmental review, the project would not be implemented. Although the conclusions of an environmental review indicate a net biological benefit, and risks of failure would be assessed, there is the possibility that a full or partial failure of a habitat enhancement project could occur. A partial failure may still represent a significant ecological benefit over pre-existing conditions. It is also possible, however, that the ecological value of the enhanced habitat would be less that that of the displaced habitat if all intended biological benefits are not achieved.

Plankton Community

Dredged material placement results in an increase in suspended particulates and a corresponding increase in turbidity within the water column. During placement, potential effects of increased water column turbidity on planktonic organisms primarily include decreased phytoplankton primary productivity due to reduction of light penetration; entrapment and sinking of plankton due to ingestion by or adhesion of particles to the plankton; and decreased survival, growth rates, and body weight concentrations of zooplankton resulting from clogged and damaged feeding appendages (USEPA 1993; O'Connor 1991; Pequegnat et al. 1978). The extent to which these effects would occur depends on the proportion of fine-grained sediments in the dredged material, which tend to remain suspended within the water column for longer periods of time than coarser material such as sand. However, the impacts to the plankton communities within San Francisco Bay are expected to be minimal since the turbidity increase is localized and most of the disposed material settles to the bottom within minutes or a few hours (USEPA 1993). Because the bulk of the material settles rapidly, reductions in light attenuation and associated reduction in primary productivity would be slight and short term, continuing only until the dredge plume dissipates (USEPA 1993). Should the disposal occur over an extended period of time, effects on the plankton population would persist until disposal ended. Some areas within San Francisco Bay (e.g., Central Bay) are dynamic and the currents bring in new plankton populations. Phytoplankton also tend to mature to reproductive life stages quickly (within a few days) and can remain viable for days to weeks, resulting in new communities every few days. Generation times for zooplankton such as copepods tend to be on the order of months (USACE and Port of Oakland 1998). Therefore, once disposal activities ended, a relatively rapid recovery of the existing plankton community would be expected to occur. Toxic effects caused by contaminants associated with suspended sediments are not expected to occur as only sediments classified as suitable for unconfined aquatic placement (based on acute toxicity tests) will be disposed in-Bay.

In the long term, habitat creation/enhancement is expected to have minimal impacts on plankton. If habitat creation/enhancement results in significant increases in the reproductive success of fish or invertebrates in the Bay, the abundance of fish and invertebrates larvae in the plankton may increase. Should an enhancement project fail such that sediment is mobilized from the site by wave and current action over a period of time, there could be adverse impacts to the plankton community in the vicinity. This would be expected to persist until sediment became stable at the site. Assuming the substrate eventually stabilized, the plankton community would be expected to recover relatively quickly for the reasons described above.

Aquatic Plants

The increase in turbidity associated with the dredged material placement would result in reduced light availability for macroalgae, tidal marsh plants and/or eelgrass present in the vicinity. Suspended solids may also be deposited on plants adjacent to areas in which shallow-water habitat may be created. This would result in plant loss. Previous studies indicate that eelgrass beds in San Francisco Bay are already limited by high turbidity and low light availability (Zimmerman et al. 1991 and 1995). Eelgrass beds near the project area may thus be vulnerable to periods of high turbidity. Eelgrass may also be more sensitive to high turbidity levels during the growing season (late spring to early summer) and during late summer and fall, when carbon reserves are stored for winter. Therefore, placement activities may have adverse effects on the condition and survival of eelgrass beds located nearby. Similar effects could occur on macroalgae and tidal marsh plants. The impact on eelgrass or tidal marsh plants would depend on its proximity to the placement area, the amount of suspended solids and turbidity produced, the velocity of the local currents, and the season. Any adverse effects on eelgrass or marsh habitat would also affect associated benthos, fish, and marine mammals and birds (USACE and Contra Costa County 1997).

The potential adverse effects (discussed above) of dredged material placement on eelgrass and other aquatic vegetation are primarily temporary. Proper planning and implementation of projects will be needed to ensure that such effects are not significant and do not have adverse impacts over the long term. If poor project planning and/or implementation, or unexpected events, result in adverse water quality or hydrological impacts in the long term (see sections 6.2 and 6.3, below), this could lead, in turn, to adverse impacts to eelgrass or other aquatic vegetation. Impacts such as reduced productivity associated with low light availability may be minimized if placement occurs during winter months when the eelgrass plants are not actively growing and flowering, and macroalgae are not growing significantly (USACE and Contra Costa County 1997). Although the risks of project failure will be assessed prior to conducting operations to enhance a site, there is the possibility that eelgrass or macroalgae may not successfully become established at a site or that establishment is slow. This could result in erosion of the placed material, which would in turn result in increased turbidity and corresponding effects on plant species in the vicinity. Slumpling of sediment into adjacent areas could also occur, which would result in burial of plant species adjacent to the site. The resulting habitat could have a lower ecological value than the pre-existing habitat. If a project to create another habitat type is proposed in an eelgrass bed, obviously this would result in the loss of the eelgrass bed and the ecological functions it supports. Such a project is unlikely to be implemented, in part because it is unlikely that it could be shown to result in a net biological benefit, as discussed in Chapter 5, above.

In the long term, habitat projects that include aquatic vegetation such as eelgrass and macroalgae would, if successful, result in the establishment of this vegetation at the site. Macroalgae may also attach and grow on structures used to contain the dredged material. The establishment of vegetation at a site would result in an increase in the extent of these valuable and limited habitats in the Bay, with the biological benefits described in following sections Due to the high ecological habitat value of eelgrass beds and tidal marsh areas, it is unlikely these areas would be considered for creating a shallower-water habitat or islands for bird use. This could represent a significant loss of valuable habitat within the Bay, especially considering the potential for full or partial failure of an enhancement project.

Benthic Invertebrates

Possible impacts on benthic invertebrates due to placement of dredged material depends on the type and amount of material being deposited, the rate of accumulation and burial time, the frequency of placement, and the type of organisms present at the placement site. Suspension and surface deposit feeders would be most susceptible to burial. Mobile infaunal deposit feeders would be more likely to survive burial by their ability to burrow upward through the newly deposited material. Critical burial depths appear to range from 5 cm for suspension and surface deposit feeders to 30 cm for active burrowers, based on various studies of critical burial depths for different benthic organisms (Nichols et al. 1978; Maurer et al. 1978). Thicknesses exceeding 5 to 30 cm could result in significant mortality, particularly to surface deposit and suspension feeders. Slow-moving epifaunal invertebrates such as seastars, sea cucumbers, and brittlestars, also have a potential for burial and possible mortality. The thinner the placement layers (e.g., less than 10 cm), the more likely these organisms will be to survive.

In addition, the dredged material may be different in sediment type (e.g. different grain size or organic content) than the existing substrate. With a change in substrate type and available organic food source, a change in the benthic community present would occur. The community that initially develops after placement would more likely be represented by species that are adapted to disturbance and are typically found in the type of substrate that comprises the dredged material. This may include species already present at the site being altered which recolonize the area following placement activities, and species introduced with the dredged material.

Recolonization after placement of the dredged material generally occurs by vertical migrations of deposit-feeding organisms through the deposited material and by larval recruitment or immigration of organisms from adjacent areas. Studies of recolonization following placement indicate that recolonization is rapid for establishing an opportunistic pioneering community (USEPA 1993). Species that are most likely to first recolonize by larval recruitment include small, near-surface dwelling, opportunistic polychaetes such as those in the Spionidae and Capitellidae families. Other species recolonizing the site include species that are able to tolerate disturbance and changes to their environment. Assuming the site is not re-disturbed, opportunistic species would be replaced over time by species typical of later successional stages, until a diverse climax community characteristic of the particular type of physical habitat developed.

Depending on the thickness of the dredged material deposit and the difference in sediment type of the created habitat from the existing habitat, effects on the benthic community may be temporary (a few months to a few years) or long term. Should the dredged material deposit be thin (<10 cm) and similar in grain size to the existing substrate, the effects would be temporary. As the deposited material becomes mixed with native material through natural deposition, slumping, resuspension, and other physical processes, the benthic community responds accordingly. Should the dredged material deposited be coarser or finer than the existing sediment, the deposit relatively thick, or eelgrass introduced, the resulting benthic community would differ from the existing community.

Dredged material used to create new shallow-water habitat in-Bay is not expected to be toxic to benthic organisms living at the site. Material that would be deposited at the site would include only sediments that passed toxicity tests.

One of the major objectives of many of the habitat creation/enhancement projects is expected to be development of a more diverse and productive benthic community that can support enhanced fish and bird use. When deep habitat is converted to shallow habitat, this is facilitated by greater light availability, greater primary production by phytoplankton and/or attached plants, and greater input of organic matter. Shallow habitats are also more accessible to foraging birds and juvenile fish and invertebrates. In some cases, an objective of converting one type of shallow habitat to another is to achieve a more desirable benthic invertebrate community (one that is more diverse, productive, or that supports important target species such as the California least tern, salmonids, smelt, herring, etc.). In addition, the structures used to contain the sediment for some of the enhancement projects would serve as substrate for barnacles, mussels, and other invertebrates to attach.

Another concern is the possible failure of an enhancement project. For example, the sediment placed at the site could become mobilized from the site by wave and current activity, and the substrate would remain unstable. The community that develops would be typical of disturbed areas, dominated by a few opportunistic species instead of a more diverse and productive community.

An additional issue is the potential for the spread of exotic species into areas that are currently dominated by native species. The majority of the introduced species have successfully become established and spread throughout the San Francisco Bay estuary because many of the introduced species are opportunistic colonizers, have short life spans, produce large numbers of young, and tolerate a wide range of physical habitat conditions (e.g. salinity, temperature, substrate types) (Nichols and Pamatmat 1988). These species could be present within the dredged material placed at an enhancement site and thus would colonize the area, or they could become established from nearby areas. They could readily out-compete other species recolonizing the enhancement site. A site-specific case analysis would be necessary to evaluate the existing benthic community at an enhancement site, and assess impacts of introducing exotic species. Many of the introduced species are prevalent throughout the bay, and a given site may already be dominated by exotic species.

Fish

Potential impacts of dredged material placement on fish resulting from increased suspended solids include impaired oxygen exchange due to clogging or laceration of gills, reduced food availability due to burial of benthic organisms, reduced visibility for foraging activities, and burial of slower moving bottom fish (O'Connor 1991). Initially, some of the species may be attracted to introduced prey such as invertebrates that were released from the dredged material (USEPA 1993). However, the dominant reaction is expected to be avoidance of the sediment plume by fish, which are highly mobile, so that effects of turbidity are expected to be negligible. Many of the demersal species such as flatfish, gobies, and sculpin should also be able to avoid burial during the placement, although they may be displaced from the area until the placement area is recolonized by prey species (e.g., polychaete worms). The effects of this temporary displacement are expected to be minimal because the displaced fish will be able to feed in adjacent areas. Some of the more sedentary species present may have more difficulty avoiding burial. Toxic effects of dredged material placement on fish both in the water column and on the bottom are not expected since only material suitable for unconfined aquatic placement will be used for creating new shallow-water habitats.

Should the placement activities occur near where fish spawn, fish eggs could be adversely affected by an increase in turbidity as a result of sediment settling directly on the eggs. Herring is of particular concern because these fish are important commercially and serve as food for a variety of fish and birds. The herring spawn on eelgrass or other firm substrates such as pilings and riprap in a number of locations within San Francisco Bay. Herring could be adversely impacted if the placement operations were to occur during spawning season (December through February). Avoiding placement when herring are spawning could mitigate this potentially significant impact on herring (USACE and Port of Oakland 1998). In the long term, spawning by herring and other species would be enhanced by creation of habitats with eelgrass or other vegetation.

Another impact to fish could result from an increase in noise generated by placement activities. Noise could disturb fish in the immediate vicinity of the placement operations. It is expected that this would result in an avoidance reaction by the fish. However, they also would avoid the area due to the sediment plume as has been observed in studies of dredged material placement impacts. These have indicated that fish migrate from the immediate vicinity of placement operations and return once placement activities have been completed (USACE and Port of Oakland 1998). Therefore, effects of noise on fish are considered to be temporary and insignificant.

Temporary disruption of the benthic community of the project site may have a temporary adverse effect on fish foraging. In the long term, however, one of the principal objectives of habitat creation and enhancement projects is expected to be improvement of habitat for fish feeding, spawning, and nursery functions. This would typically be achieved through development of a more diverse and productive benthic community, the refuge provided by shallow water (and by eelgrass or other vegetation when present), and the special spawning substrate provided by shallow habitat or eelgrass/vegetation. Should an enhancement project fail to some extent, the resulting habitat could be less valuable than the pre-existing habitat, and the desired effect of increased foraging, spawning, or nursery habitat for fish may not occur.

Aquatic Birds and Marine Mammals

Generally, adverse impacts on marine mammals and birds in the vicinity of the placement site would be localized and temporary. Possible impacts include reduced visibility for foraging activities, reductions in available prey, alteration of passage routes to avoid the turbidity and ship traffic, occurrence of ship-following behavior patterns in birds, and ingestion of contaminated prey items. Although reductions in water clarity due to increased turbidity during placement may limit the foraging efficiency of both birds and mammals, significant reductions in clarity are generally concentrated at the release site, and are of short duration (hours to a few days). Availability of prey items, such as fish, krill, and other zooplankton, may be temporarily reduced in the placement area because these organisms likely would escape or avoid the sediment plume (USEPA 1993). In addition to the placement effects, the existing benthic habitat would be changed or lost as a result of creating new shallow-water environments. There would be a loss of prey until new benthic and corresponding fish communities become established. Foraging success within the immediate placement area would be limited temporarily. However, the birds and mammals are capable of foraging in unaffected areas within the region and should not be significantly affected by any reduction in prey during placement operations.

Normal feeding activities and passage routes may also be altered by the increased ship traffic during placement activities as a result of birds following the barges and tugs, or birds and mammals avoiding the noise created by the ships transiting to the site, or general construction noise and disturbance (USEPA 1993). However, these behavior alterations would be temporary, occurring predominantly during placement activities. Seasonal restrictions would be used to minimize disturbance of birds and mammals during sensitive breeding and nesting seasons. Since only material that is suitable for unconfined aquatic disposal would be used for creating new shallow-water habitats, toxic effects to marine mammals and birds, through ingestion of prey items that have been contaminated by the dredged material, are unlikely.

In the long term, the creation of new shallow-water habitat is expected to enhance the habitat, and increase the productivity in the area. This should increase the food available for the birds and mammals occurring in the area. Some types of shallow habitat, such as eelgrass, shallow subtidal areas, mud or sand flats, and salt marsh, are specifically intended to provide enhanced foraging habitat for birds such as the California least tern, the California clapper rail and other shorebirds, and mammals such as the salt marsh harvest mouse. Obviously, the target bird species are expected to benefit from islands designed for bird roosting or nesting. These islands provide increased protection of birds from mammalian predators and human interference.

Although the majority of the impacts to birds and marine mammals are expected to be localized and temporary, there is the possibility an enhancement project either partially or fully fails. This could ultimately result in a new habitat that is less valuable than the original habitat, including decreased foraging habitat for birds and mammals.

Threatened, Endangered, and Sensitive Species

As with the other species addressed above, dredged material placement may have temporary adverse impacts on threatened, endangered, or sensitive species. Species that occur within San Francisco Bay include the California least tern, California brown pelican, Western snowy plover, California black rail, California clapper rail, winter-run chinook salmon, delta smelt, tidewater goby, Sacramento splittail, green sturgeon, longfin smelt, salt marsh harvest mouse, and a number of tidal marsh plant species as listed in section 4.2.1.7. Potential impacts such as impaired visibility for foraging and reduced food availability within the area of placement, which would alter normal feeding or passage activities, would be temporary and localized at the release site (USEPA 1993). As discussed above, avoidance responses by fish and birds as a result of increased noise during placement operations and transport of dredged material to the site would be expected to be temporary and insignificant. In the long term, habitat creation and enhancement projects are expected to improve feeding and reproductive habitat and resources for these species.

Although California brown pelicans roost within San Francisco Bay, this species does not breed in the area. Brown pelicans may forage in the vicinity of areas in which shallow-water habitats may be created; however, this species occurs throughout the San Francisco Bay area and is not expected to be significantly affected by placement operations. If variations in normal feeding patterns or passage activities associated with ship-following behavior patterns (as observed in other bird species) occur, these behavior changes would be temporary, generally continuing only during placement operations. If habitat creation and enhancement projects improve fish production in San Francisco Bay, this will improve feeding resources for pelicans.

Least terns are also likely to avoid the immediate area during placement operations, with an insignificant effect on feeding success for these species. Least terns have been observed foraging primarily along the breakwaters and shallows of the southern shoreline of NAS Alameda and in Ballena Bay during May through August; foraging may only be impacted if the new shallow-water habitat is created in this general area. The food supply for terns, which feed primarily on surface fish, is expected to return to normal after placement operations end. Therefore, short-term impacts to least terns are expected to be minimal. Over the long term, some shallow habitat projects will be intended to create new forging habitat for least terns, and to generally improve foraging resources for least terns by improving fish production.

If a project is constructed near their habitat, shore and marsh species such as the snowy plover, California clapper rail, California black rail, and the salt marsh harvest mouse could also be disturbed by construction noise and activity, which could affect feeding, breeding, and nesting. Seasonal restrictions on construction could minimize such effects. If the marsh habitat for such species is replaced as part of a habitat enhancement project, these species would be displaced and adversely affected. Again, such a project is unlikely to be implemented, because it is unlikely that a net ecological benefit could be shown. If an existing marsh or shoreline is adversely affected by a nearby habitat enhancement project, due to water quality or hydrodynamic effects, this would result in degradation of habitat for these species.

The winter-run chinook salmon may pass through San Francisco Bay during upstream and downstream migration (November to May). Similarly, green sturgeon may migrate through the area during the winter and fall to spawn in the Sacramento River in the spring. Steelhead trout also migrate through San Francisco Bay to spawn in the Sacramento, Napa, and Petalums rivers and in Sonoma Creek. The peak migration period for both adults and outmigrating juveniles is January through May. Coho salmon currently make minimal use of the Sacramento River and other drainages to San Francisco Bay. For these anadromous fish species, migrating adults could effectively avoid the immediate placement site, and so avoid significant effects. Juveniles occur primarily in shallow water near the shoreline, and could be adversely affected by placement operations in nearshore areas in the short term. This effect could be avoided by not conducting placement operations during outmigration periods. However, conversion of a deep-water habitat to a shallow-water habitat would create more habitat for juveniles to use as a nursery area, providing food and refuge. Enhanced habitat could also provide improved foraging for adult salmonids.

Sacramento splittail and delta smelt may occur in the vicinity of the project area should a site be established in Suisun Bay, Carquinez Strait, or San Pablo Bay, although delta smelt are generally not found farther downstream than Suisun Bay. Longfin smelt could occur throughout San Francisco Bay, although is expected to be less abundant in the South Bay. Tidewater gobies may occur in the project area if a site were established near marshes and creeks. All of these fish would likely avoid the immediate placement site where effects could occur. As an open-water species, longfin smelt are the most likely to be found in the vicinity of one of the placement sites. As indicated for salmon, new shallow-water habitat is expected to benefit these species in the long term.

Potential effects (as described above for fish in general) on adults such as turbidity effects and reduction in food resources, would be very limited in magnitude and duration. Salmon smolts/juveniles could be disturbed by the placement activities and increased turbidity could clog gills. Although mortality is possible, the smolts would likely move to other areas during placement operations. The benthic community is expected to recover quickly enough following dredging that there should be no long-term effect on potential food sources for the fish in San Francisco, San Pablo, and Suisun bays. The potential for impacts on the winter-run chinook salmon is further reduced because migrating adult chinook salmon have stopped (or almost stopped) feeding by the time they enter the Bay on their upstream migration. Over the long term, creation of additional shallow-water habitat within San Francisco Bay has the potential to benefit the threatened, endangered, and sensitive species occurring within the San Francisco Bay estuary.

Although the risk of failure of enhancement projects will be evaluated prior to project implementation, there is the possibility that a project will partially or fully fail. Consequently, improved habitat for special status species may not occur, or the resulting habitat may not support these species as intended or as the original habitat did. As discussed in the sections above, the placed sediment may not be stable and could result in increased turbidity within the water column or slumping into adjacent areas (and burial of the adjacent biological community).

In addition to project failure, conducting enhancement projects within eelgrass beds or tidal marsh areas would need to be fully evaluated to assess whether there actually will be a significant enhancement over these already valuable and critical habitats within the bay. Loss of eelgrass beds would indicate a decrease in important nursery and foraging habitat for special status bird and fish species. Similarly, loss of tidal marsh habit would represent a decrease in important habitat for special status plant and animal marsh species.

Mitigation Measures

Mitigation measures to reduce short-term impacts on the biological community during placement operations would include accurate positioning to ensure that dredged material is confined within the site boundaries so that adjacent communities are not affected. Measures may also include monitoring the placement operations and potential effects on the existing pelagic and benthic communities. This could include the following measures:

- Monitoring of dredged material transport following placement in order to assess whether the material remains within the placement zone or is transported out of the placement site.

- Inspection by a qualified inspector to ensure that transportation and placement of sediments occur within the designated discharge zone and that compliance with all permit terms and conditions is met.

- Accurate and precise navigation and positioning to ensure that placement occurs within the designated site boundaries. A record of the barge navigation course while inside placement boundaries throughout placement operations may be maintained.

- Scheduling construction to avoid sensitive periods for protected species, such as salmon migration periods, nesting periods for birds such as least terns or clapper rails, etc.

Other monitoring could include making observations and sampling to identify if adverse impacts on the marine bird, mammal, or mid-water fish populations have occurred as a result of the surface and water column dredge plume, and to indicate if the dredged material footprint extends outside of the designated site boundary. An observer would be present to redirect the placement operation away from and thus avoid effects on these biota. To minimize impacts on spawning and nursery areas, measures to restrict the spread of suspended sediments could also be considered. These measures may include the use of silt curtains or protective berms to prevent sediment migration.

Long-term mitigation measures would be implemented to maximize the biological success of the project:

- Long-term monitoring of physical and biological features of the project site to determine whether there is satisfactory progress toward project objectives.
- Adaptive site management, including any needed corrective actions.

6.1.1 Eelgrass

The creation of shallow-water habitat supporting eelgrass beds would, over the long term, increase the amount of this limited habitat, and greatly benefit benthic invertebrates, fish, birds, and marine mammals occurring within San Francisco Bay. Eelgrass beds are highly productive and provide refuge and valuable nursery habitat for many fish and invertebrate species. They also provide spawning habitat for fish such as Pacific herring, and various bird species forage for fish within the beds. Eelgrass beds would generally be more productive than deep-water habitats and other shallow-water habitats within San Francisco Bay.

Short-term impacts such as loss of the existing benthic community, impacts to organisms associated with placement operations during creation of the shallow-water habitat, and initial avoidance of the area by fish, birds, and marine mammals until placement operations have ceased and/or the eelgrass and benthic community have become established are expected to be insignificant or mitigable. Should the adjacent habitat contain eelgrass, methods to minimize impacts to these beds may be taken as described above in section 6.1. Should herring spawn in the vicinity or juvenile salmon occur nearby, placement operations for creating the shallow-water habitat should occur outside the salmon outmigration period or the herring spawning period.

Creating eelgrass habitat can be difficult and has not yet been done successfully in San Francisco Bay. Based on previous eelgrass transplant and mitigation projects within the Bay, there is the possibility that eelgrass will only partially become established over time or that eelgrass will not successfully grow at the project site. The resulting habitat would likely not have as substantial benefits as expected with the establishment of an eelgrass community. It is also possible that the resulting habitat may not be as productive as the pre-existing habitat.

6.1.2 Unvegetated Shallow Subtidal Habitat

Unvegetated shallow subtidal habitat would consist of gently sloping areas with coarse to fine sediment substrate that would be less than 20 feet deep. The benthic invertebrate community that would eventually develop in these areas would be expected to be more diverse and productive than most of the deep-water habitats, especially the artificially maintained deep-water areas such as navigation channels. Other benefits to creating this type of habitat would be that it would provide habitat for fish favoring shallow water, and for epibenthic invertebrates such as crabs, shrimp, snails, and echinoderms. It would also serve as refuge and nursery habitat for juvenile fish and invertebrates, although it would lack the structure and productivity that eelgrass beds provide. However, given the right conditions and elevation (e.g., less than 10 feet deep), it is possible that this habitat may eventually be colonized by eelgrass. This habitat would also benefit birds, such as the California least tern, by increasing production of forage fish.

Short-term impacts associated with placement of dredged material in the creation of this shallow-water habitat are described above under the general impacts (section 6.1). Adverse impacts to fish and other organisms would be minimal or mitigable. The benthic community that eventually develops would differ from the existing benthic community, although it is expected to be more diverse and productive. The fish community may change to some extent, although increased nursery and foraging habitat for fish would benefit fish populations within the estuary. As indicated above, foraging habitat for birds would increase.

Although the construction of this shallow-water habitat would be expected to result in a more diverse and productive biological community than exists in deep-water locations and in navigation channel or harbors, it would not necessarily be an improvement over other shallow-water habitats within San Francisco Bay. It would be necessary to evaluate this on a site-specific basis. Locations in which this type of habitat would be created would generally be more likely in deep-water locations than in shallow-water locations.

6.1.3 Intertidal Mud/Sand Flats

The benefits of creating intertidal mud or sand flats would be the addition of more valuable feeding and refuge habitat for small and juvenile fish, and foraging habitat for larger fish at high tide. It would also provide increased feeding habitat for shorebirds at low tide. Infaunal and epifaunal communities that would develop in these areas are expected to be diverse and productive. Benthic invertebrate species that colonize the area would be those typically found in San Francisco Bay mud/sand flats, such as a variety of clams, gastropods, polychaetes, and small crustaceans. These serve as a valuable food source for fish as well as waterfowl and shorebirds. Depending on the elevation, substrate, and other factors, these areas could also be colonized by salt marsh plant species.

Short-term impacts associated with disposal of dredged material in the creation of this intertidal habitat would be comparable to those described for the creation of unvegetated shallow-water habitat. The benthic community that eventually develops would differ from the existing benthic community, although it is expected to be more diverse and productive. Fish populations within the estuary would benefit in that important nursery and foraging habitat for fish would be increased. Foraging habitat for birds would also increase. As described for the creation of unvegetated shallow-water habitat, the construction of intertidal mud/sand flats would be expected to be most beneficial when the intertidal habitat is created in existing deep-water locations, than existing shallow-water habitats.

As described in section 6.1, it is possible that the creation of the intertidal mud/sand flats may not be successful. For example, the placed sediment may be unstable and either slump or erode from the site. The benthic community that develops would be more characteristic of an unstable or disturbed community (i.e., short-lived, shallow surface-dwelling, opportunistic species). This resulting community could be less productive than the original community. Site-specific analyses will be necessary to evaluate the potential for success or failure of a given project prior to project implementation.

6.1.4 Salt Marsh

This habitat type would consist of gently sloping areas with medium to fine sediments at elevations in the upper part of the intertidal range. Salt marshes support a variety of plant species such as pickleweed, saltgrass, and cordgrass, as well as algae. Various invertebrates (e.g., amphipods, snails, and crabs) inhabit the salt marshes. San Francisco Bay salt marshes also provide important habitat for the California clapper rail, an endangered species, and the California black rail, a threatened species, and essentially the only habitat for the endangered salt marsh harvest mouse. Existing habitat for these species in San Francisco Bay is very limited, as most of

San Francisco Bay's salt marshes have been lost through diking, filling, and other shoreline development. Increasing habitat for these rare species is a main impetus for creating / restoring salt marsh habitat. Salt marshes also provide feeding and nursery habitat for fish, and foraging habitat for shorebirds and waterbirds.

Short-term impacts to the existing biological community associated with the construction of these wetlands are described under general impacts above (section 6.1). Impacts would be expected to be insignificant or mitigable. The existing benthic invertebrate community would change to one more characteristic of a salt marsh. The fish community would also change, although salt marshes provide excellent feeding and nursery habitat for a variety of fish. There would also be increased foraging and resting habitat for shorebirds and waterfowl. The creation of this type of habitat would be highly beneficial for the conservation of the California clapper rail, California black rail, and salt marsh harvest mouse.

As with other enhancement projects, the possibility exits that the creation of salt marsh habitat will only be partially successful or fail entirely. For example, tidal marsh plant species transplantations may not be successful, or the establishment of these species may be slow, leading to the erosion of placed material. This could lead to additional impacts as described in section 6.1. Depending on the location of the enhancement site, the resulting habitat could also be less productive than the pre-existing habitat.

6.1.5 Islands for Bird Use

The creation of islands for bird use would be beneficial to a variety of bird species in San Francisco Bay, as the islands could provide roosting and nesting habitat. Birds that may benefit include least terns, herons, egrets, waterfowl, and shorebirds. Creation of the islands would introduce new intertidal habitat on the island slopes, which would benefit invertebrates such as crabs, mussels, barnacles, and clams. It also would provide substrate for macroalgae to attach and grow.

The islands could be created on existing shallow-water habitat or constructed as part of a larger, shallow-water enhancement project. The construction of the islands would result in loss of the existing benthic habitat. However, the shallow intertidal habitat on the island slopes is expected to be more productive than dredged areas and possibly deep-water, coarse-grained sediment habitats. There would also be some loss of fish and marine mammal foraging habitat, although this would represent a small fraction of their overall foraging habitat within San Francisco Bay. Should the island be constructed in existing shallow-water habitat, there may be a small loss of shallow-water nursery habitat for fish and invertebrates, although this is not expected to be significant, considering the shallow habitat created on the slopes of the islands.

If an island were constructed within an existing eelgrass habitat, mudflat, or tidal marsh area, a significant loss of eelgrass, mudflat, and tidal marsh habitat would occur. Other impacts to eelgrass nearby (if present) and the existing biological community associated with disposal of the dredged material are described above under the general impacts (section 6.1). Creating bird islands would also result in the loss of a corresponding area of water surface. A site-specific analysis would be necessary to evaluate the habitat benefits and losses associated with the creation of islands for bird use.

6.2 WATER QUALITY

This section discusses the potential impacts to water quality of creating or enhancing habitat. It is assumed that the sediment to be used for beneficial reuse is suitable for unconfined aquatic disposal/reuse, and therefore no adverse effects on sediment quality are expected. The potential impacts to water quality due to conversion of one habitat type to another are discussed below in general terms. For most water quality parameters, the actual impacts that could occur will be site-specific, and should be determined on a project-specific basis. In general, converting a deep-water habitat to a shallow-water habitat will cause the habitat to take on the water quality characteristics of a shallow-water habitat. As discussed in section 4.2.2, several differences in water quality parameters exist in San Francisco Bay between deep-water and shallow-water areas. However, it should be noted that many of these differences may be related more to proximity to a point source or area of high runoff, rather than to water depth. Construction of enhancement projects would result in short-term impacts to water quality, as described in the following sections.

The potential for physical failure of a habitat enhancement project must also be taken into account when considering impacts to water quality. This issue is discussed in Chapter 5, and the potential water quality impacts associated with physical failure are discussed under each applicable parameter below.

Impacts by Water Quality Parameter

Salinity

The placement of dredged material may have local, short-term effects on salinity within beneficial reuse areas. There is often a salinity gradient with depth at most locations throughout the San Francisco Bay estuary. Placement of material can cause an increase in vertical mixing, but any associated changes in salinity are expected to be very short-term and limited to the placement site (USACE et al. 1998). Since salinity intrusion is an important issue affecting the Sacramento and San Joaquin Delta region, the salinities of the dredging and the placement sites would be monitored to ensure that there is no adverse salinity effect at the placement site. It is expected that no marine sediments would be placed in freshwater sites, such as the Delta. No long-term effects on salinity are expected within potential placement areas, as long as the salinities of the dredged material and placement site are adequately matched.

Temperature

Most changes in water temperature would be restricted to the descent phase of dredged material placement. In 1972, the Corps San Francisco District monitored water quality variables during dredging and placement activities. Although these studies took place at relatively shallow in-Bay disposal sites, their findings can also be extrapolated to deep-water sites. In general, temperature was not substantially influenced either horizontally or vertically during placement operations. Measurements of temperature varied less than 1°F. The greatest effects were typically measured within 5 minutes after release and overall effects dissipated within 10 minutes (USACE 1976a). The placement of dredged material is therefore not expected to significantly affect this water quality parameter in the short term. Over the long term, a shallow-water created habitat may experience greater diurnal fluctuations in water temperature than would an existing deep-water habitat. Very large beneficial reuse projects have the potential to alter the surface area and volume of waters in San Francisco Bay. Such projects could potentially decrease the size, volume, and dynamics of the tidal prism, and alter water quality and tidal flushing. The Bay waters help moderate temperatures in San Francisco Bay and an extreme reduction in current velocities and tidal flushing could increase water temperature fluctuations. Greater diurnal and seasonal water temperature fluctuations would be expected in such a scenario.

Dissolved Oxygen

The placement of dredged sediment has the potential to affect dissolved oxygen (DO) levels at any placement site, particularly in waters near the Bay floor. Short-term depressions in DO levels were measured in waters immediately adjacent to the Carquinez disposal site during placement of material from the Mare Island Strait in 1973. DO levels near the Bay floor declined from 80 to 85 percent to 20 to 30 percent saturation within several minutes after material was released from the barge, but recovered to ambient levels within 10 minutes (USACE 1976a). The extent of this type of effect depends on the amount of oxygen-demanding substances present in the material. Anoxic sediments containing reduced substances such as hydrogen sulfide would cause the greatest temporary depression in DO levels at a placement site. The effects of dredged material placement on DO levels in Bay waters are usually short term, generally limited to the plume associated with each dump, and confined to the placement area and immediately adjacent waters. However, placement of dredged material in areas where DO levels are already depressed, and/or placement at high dumping frequencies, could cause more extensive water quality impacts (USACE et al. 1998). These impacts would not be expected to be long term in nature, provided the creation of habitat does not significantly reduce flushing rates. If, however, a deep-water area is converted to a shallow-water habitat, circulation and flushing may be reduced and, as a result, dissolved oxygen levels will likely decrease. This could represent a long-term impact to dissolved oxygen in the water column if levels frequently exceed water quality objectives. Proper site design and selection will minimize the likelihood that this water quality parameter is not impaired in such a situation.

pH

The placement of dredged material may change the pH of waters at placement sites if the pH of the dredged material is significantly different than that of the placement site. However, such an effect is expected to be of extremely short duration and limited to the placement site area (USACE et al. 1998). Dredged material placement is therefore not expected to significantly affect this water quality parameter in the short term or long term.

Total Suspended Solids

The placement of dredged material causes a temporary increase in the level of suspended material (turbidity) in site waters. Most of the material in the descending cloud reaches the substrate, but a small percentage (approximately 10% of sediments dredged from a clamshell dredge) of finer material remains in the water column (SAIC 1987). In addition to this material, a more dense cloud of material forms near the bottom after dynamic collapse of released material. This near-bottom plume of highly concentrated suspended solids spreads horizontally until its momentum has dissipated (USACE et al. 1998).

The turbidity plume resulting from dredged material placement typically disperses, and water column TSS levels return to near-background levels within 15 to 20 minutes of release (Reilly et al. 1992). The plumes have been observed to migrate in the direction of the current at the time of discharge (SAIC 1987). For example, monitoring of the vertical profiles of turbidity plumes at the Alcatraz site in 1976 showed that the maximum increases in suspended solids on site occur at near-bottom depths. At a depth of 1 meter, suspended solid concentrations rose from roughly 25 mg/L TSS (background) to approximately 275 mg/L TSS 50 meters from the point of release, then declined again to near-background levels 400 meters from the release point. Suspended sediment concentrations at 5 and 9 meters above the Bay floor were much lower, ranging from 25 to 75 mg/L TSS (USACE 1976a).

At any unconfined aquatic placement site, placement of dredged material is therefore expected to cause short-term changes in water column turbidity with each release of material. If material is placed within a confined site — confined by the shoreline, berms, or other structures — these short-term changes may be slightly reduced. These changes are primarily limited to near-bottom waters within and immediately adjacent to the placement site. At placement frequencies exceeding or approaching the time it takes for the near-bottom plumes to settle or disperse, the effect on this water quality parameter would be greatly increased. In addition, the nature and significance of the water quality impact depends on the characteristics of the embayment, as well as the characteristics of the dredged material being disposed. Areas and seasons of low turbidity would be affected more than areas or seasons with naturally higher levels of turbidity (USACE et al. 1998). In addition, if a habitat containing primarily coarse-grained sediment is converted to a habitat of primarily fine-grained sediment, higher turbidity levels would be expected.

The potential exists for physical failure of an enhancement project if physical features such as elevation and slope are not maintained. If the dredged material cannot be maintained at the placement site, elevated TSS levels may occur in the vicinity and adjacent areas as the material is transported off-site. TSS levels would be expected to subside once the material is no longer being transported.

Nutrients

The magnitude and extent of changes in nutrient levels as a result of dredged material placement has not been extensively monitored in San Francisco Bay. Short-term changes in ammonia levels are expected to occur, particularly in conjunction with the near-bottom turbidity plume described above under Total Suspended Solids. However, oxidative removal of ammonia from the water column generally occurs quite rapidly in well-oxygenated waters such as those of the Estuary (USACE et al. 1998). In addition, placement sites may experience short-term increases in water column nutrient levels if there is a significant difference in concentrations between the site sediment and the placement sediment. Also, if creation of a new habitat type results in decreased circulation and/or flushing at the site, nutrient levels could occasionally increase to levels above water quality objectives. This may represent a long-term impact to nutrient levels in the water column. Proper site design and selection will minimize the likelihood that this water quality parameter is not impaired in such a situation.

If physical failure of an enhancement project occurs, dredged material may be transported away from the placement site. If this situation occurs, the water column may experience increases in nutrient levels in areas adjacent to the placement site. Nutrient levels would be expected to subside once the material is no longer being transported.

Metals and Organic Chemicals

The types of potential effects described in this section are minimized by the fact that only sediment suitable for unconfined aquatic disposal would be used for habitat creation/enhancement.

The placement of dredged material has the potential to remobilize metals associated with sediment particles into the water column. The primary factors controlling the degree of mobilization are the oxidation-reduction potential of the sediment, the pH of the sediment pore water and overlying water, and the salinity of water at the site. Higher levels of oxygen in the site water than in the sediment would promote some initial oxidation of substances in dredged material, which would, in turn, influence the adsorption and desorption of chemical contaminants to and from complexes (e.g., with sulfides). The typically higher pH of Central Bay waters compared to dredged material would also promote desorption of contaminants (USACE et al. 1998). Conversely, higher on-site salinity, which is a less important factor than pH or redox potential, would serve to increase the adsorption of contaminants onto sediments (U. S. Navy 1990).

Disposal plume studies performed by the Corps of Engineers have shown that levels of chlorinated hydrocarbons increase immediately after placement, then return to background levels within 30 minutes (USACE 1976b). As with metals, the potential impact of short-term increases in organic pollutant concentrations in the water column depends on the background concentrations of pollutants (USACE et al. 1998).

The overall impact of short-term increases in contaminant levels in the water column depends on the background concentrations already present in the water column, whether water quality objectives have been exceeded, and the extent of the mixing zone within which concentrations are elevated above ambient levels. The highest risk of environmental impact from this phenomenon occurs when placement of dredged material could cause increases in water column concentrations above EPA criteria or state water quality objectives. This is particularly true in cases where water quality within an embayment is already impaired (USACE et al. 1998).

Although higher levels of metals and organic chemicals have been observed in shallow-water areas than in deep-water areas (section 4.2.2), it is not expected that converting a deep water habitat to a shallow-water habitat would necessarily cause an increase in contaminant concentrations, as this water quality parameter is generally affected more by spatial and seasonal patterns than by water depth. If, however, creation of a new habitat type results in decreased circulation and/or flushing at the site, metal and organic chemical concentrations could occasionally increase to levels above water quality objectives if there is any local input of chemicals. This may represent a long-term impact to contaminant levels in the water column. Proper site design and selection will minimize the likelihood that this water quality parameter is not impaired in such a situation.

If physical failure of an enhancement project occurs, dredged material may be transported away from the placement site. If this situation occurs, the water column may experience increases in metal and organic chemical levels in areas adjacent to the placement site. Chemical levels would be expected to subside once the material is no longer being transported.

Sediment Quality Impacts

Converting one habitat type to another may result in changing the physical and chemical characteristics of the sediment. These impacts would depend on the characteristics of the sediment disposed. Physical and chemical characteristics of the sediment likely to be affected include the grain size distribution, pH, total organic carbon content, sulfides, and other chemical concentrations.

Mitigation Measures

The following mitigation measures would reduce impacts to water quality related to placement of dredged material at sites chosen for habitat enhancement.

- Monitor placement activities for turbidity conditions as required by regulating agencies.

- Control flow into the Bay from placed sediment with appropriate measures such as silt curtains (where current velocities are low enough), submerged berms, or containment dikes.

- Place dredged material in accordance with regulating agency standards for volume limits and scheduling.

- Minimize TSS levels during sediment placement activities by using one of the following methods: slow opening of a bottom-dump barge (if used), placement of a thin layer of sand on top of fine-grained sediments prior to rapid bottom dumping, or use of a diffuser at the end of the sediment discharge pipe.

Impacts by Type of Created Habitat

Eelgrass

The potential impacts to water quality for an eelgrass created habitat are expected to be similar to those described above.

Unvegetated Shallow Subtidal

The potential impacts to water quality for an unvegetated shallow subtidal created habitat are also expected to be similar to those described above.

Intertidal Mud/Sand Flats

The potential impacts to water quality for an intertidal mudflat or sandflat created habitat are expected to be similar to those described above. In addition to these impacts, an increase in total suspended solids would be likely to occur if a habitat consisting primarily of coarse-grained sediment is converted to a habitat containing primarily fine-grained sediment.

Salt Marsh

The potential impacts to water quality for a salt marsh created habitat are expected to be similar to those described above. This type of habitat would also be susceptible to an increase in total suspended solids if converted from a coarse-grained to fine-grained sediment type. However, once established, the roots and stems of the salt marsh plants may be capable of removing some of the suspended solids from the water column. In addition, salt marsh plants are generally capable of removing excess nutrients from the water column if those conditions exist.

Islands for Bird Use

The potential impacts to water quality for island habitat created for bird use are expected to be similar to those described above. In addition, increased bird droppings may result in higher fecal coliform and nutrient levels, although the impact would be very localized.

6.3 HYDRODYNAMICS

Habitat enhancement projects have the potential for impacting hydrodynamics in San Francisco Bay. The impacts could include changes in circulation patterns, current velocity, sedimentation patterns, water quality, and surface area and volume of the Bay. Depending on the design, location, and size of the project, impacts could be negligible, localized, affect the surrounding areas for large projects, or cumulatively affect the region. An evaluation of site-specific conditions is important in determining the potential impacts to hydrodynamics.

Deep-water areas in San Francisco Bay generally have strong tidal currents, particularly in the narrow straits separating the major embayments and in the narrow mid-Bay channels. Current velocities are much lower in the lateral shoal areas, where shallow-water habitat is typically found. When creating or enhancing shallow-water habitat, some modifications to existing circulation and current patterns could be necessary to match the circulation/flushing requirements of the newly created habitat. In general, modification of existing shallow-water habitat to another form of shallow-water habitat is not expected to cause significant changes to existing hydrodynamics, but should be subject to site-specific analysis. Conversely, current velocities could decrease when converting deep-water areas to shallow-water habitat. This is not considered an impact, provided the modified currents and circulation are beneficial to the new habitat and surrounding habitat areas are not affected. However, unanticipated problems or conditions can occur at beneficial reuse project sites that could lead to hydrodynamic impacts. For example, changes to circulation patterns due to site construction could cause adjacent areas to silt in, which would degrade habitat and water quality. Similarly, physical failure of a beneficial reuse site could lead to movement of sediments into surrounding habitat areas.

Beneficial reuse projects can alter the surface area and volume of waters in San Francisco Bay which could potentially decrease the size, volume, and dynamics of the tidal prism, alter water quality, tidal flushing, and change sedimentation patterns in the Bay. The Bay waters help moderate temperatures in San Francisco Bay and an extreme reduction in current velocities and tidal flushing could increase water temperature fluctuations (see section 6.2). For very large projects, a site-specific analysis could be necessary to determine whether circulation changes in San Francisco Bay would impact local temperatures and climate.

Beneficial reuse sites that require radical changes in hydrodynamics are generally not suitable candidates for habitat enhancement. For example, rocky-bottom habitat is probably not suitable for creating shallow-water habitat because of strong tidal currents (see Chapter 5). Habitats such as mud flats or salt marshes could not be established at this existing habitat type without substantial engineering (e.g., breakwater construction) to reduce current velocities. Furthermore, deep-water, rocky-bottom habitat is generally found in navigation channels and establishing shallow-water habitat in these areas could create navigation hazards.

Beneficial reuse sites should be selected so that the new habitat type is suitable for the existing hydrodynamic conditions, or only minimal engineering is required to establish suitable circulation patterns for the newly created habitat.

Mitigation Measures

The following mitigation measure would ensure that significant hydrodynamic changes do not occur, or that modified current velocities and circulation patterns are acceptable to the new habitat and do not create water quality problems.

- An evaluation of site-specific conditions will determine the specific measures required for each project. An example is the construction of berms or breakwaters.

Impacts by Type of Created Habitat

Eelgrass

Eelgrass habitat requires limited wave energy to maintain a suitable substrate, and good flushing and circulation to ensure adequate water quality. Eelgrass habitat would be created by filling deep-water sites with dredged material or amending shallow-water areas with dredged material to enhance eelgrass habitat. Filling of deep-water areas is expected to reduce current velocities and/or water circulation. Proper site selection and design will ensure that the new hydrodynamics will support eelgrass habitat, will maintain suitable substrate (i.e., sediments will not be washed away or silted over) and habitats in surrounding areas will not be impacted. However, unanticipated problems could occur which would lead to hydrodynamic impacts as described above.

Unvegetated Shallow Subtidal

This substrate type would be at elevations above –20 feet MLLW, although most projects would probably target elevations above –10 feet MLLW based on habitat value. Potential impacts to hydrodynamics are similar to those described for eelgrass habitat. Changes to site hydrodynamics are not considered negative impacts, provided that the current velocities and circulation are beneficial to this habitat type, sediments remain in place, and surrounding areas are not impacted.

Intertidal Mud/Sand Flats

Intertidal mud and sand flats consist of very gently sloping areas with fine sediment substrate. This habitat type is found in protected and unprotected parts of San Francisco Bay. For beneficial reuse projects, areas sheltered from wind-driven waves (e.g., behind spits, within estuary channels) and flushing by low tidal currents may provide more favorable conditions for project success. Amending existing shallow-water habitat to create mud flats has the smallest impact on hydrodynamic conditions. Site-specific assessment and design determines the success of creating mud flats in deep-water areas. However, hydrodynamic impacts could occur due to unanticipated conditions as described above.

Salt Marsh

Hydrodynamic impacts for creating salt marshes are similar to those described for mud flats. Salt marshes are vegetated mudflats that exist at a higher elevation (+3 feet to +8 feet MLLW) than mud flats and found in protected and less protected parts of the Bay, although areas well protected from wind-driven waves may provide more favorable conditions for habitat enhancement.

Islands for Bird Use

This habitat type consists of small islands for bird nesting/roosting constructed in offshore areas. Islands can be constructed in high or low current areas; impacts to hydrodynamics are dependent on water depth where these islands are created, the number and size of the islands, and their location. In shallow-water areas with low currents, a bird nesting/roosting island would generally not have a significant impact on the existing circulation patterns. However, creation of a series of large, extensive islands in shallow-water areas could reduce current velocities and cause poor tidal flushing. In very high current areas (deep-water, rocky bottom), eddies could form around the islands and cause scour. Areas with high currents are generally not considered suitable for habitat enhancement (see Chapter 5).

6.4 TRANSPORTATION AND NAVIGATION

Impacts to transportation and navigation depend on the location of new habitat, the size of the created habitat, and whether deep-water areas are filled to create shallow-water habitat. San Francisco Bay is used heavily for vessel transportation and navigation (e.g., ferries, cargo ships, tankers, pleasure craft). Although navigation channels are maintained within San Francisco Bay, smaller vessels are likely to travel outside the navigation channels in the most expeditious routes possible. Therefore, filling deep-water areas to create shallow-water habitat has the potential for impacting navigation.

Inactive navigation channels, such as those adjacent to closed military installations, may be suitable for shallow habitat creation. However, impacts to existing navigation use must still be considered. At a minimum, areas within the existing navigation channels of San Francisco Bay should be avoided as habitat creation/enhancement sites. As indicated in section 6.3, some areas within the navigation channels (e.g., central Bay) consist of rocky and coarse-grained sediment habitat and their hydrodynamic conditions are not suitable for habitat enhancement. More importantly, a shallow-water habitat in a navigation channel would be a hazard to deep-draft vessels. Narrowing of navigation channels is an unacceptable alternative.

Potential impacts to navigation should be considered when locating habitat enhancement sites. In general, deep or shallow-water areas located adjacent to land masses are most likely to provide favorable conditions for habitat enhancement. In addition, an assessment of possible navigation impacts should be made if a habitat enhancement site should fail (e.g., release/movement of sediments due to physical failure could reduce the depth of nearby areas used for navigation).

Mitigation Measures

Sites for habitat enhancement should be selected so that navigation impacts are minimized. In situations where navigation impacts are evaluated and considered acceptable, measures should be taken to minimize risk to vessel traffic. These measures include:

- Coordinating activities with U.S. Coast Guard Vessel Transportation Service (VTS) during all phases of habitat planning and construction,
- Alert vessels day and night by marking and lighting the shallow-water habitat (e.g., day markers in shoal areas) in accordance with U.S. Coast Guard regulations,
- Update NOAA nautical charts to show markers and shoal areas.

Impacts by Type of Created Habitat

Eelgrass

Eelgrass beds generally occur in shallow subtidal areas, in depths ranging from 0 to –6 feet MLLW. Potential impacts to navigation are expected to be as described above. Modifying existing shallow-water habitat to create eelgrass beds would generally not impact navigation. Filling deep-water areas to create eelgrass habitat may impact navigation if created in open parts of the Bay. Eelgrass beds require protection from strong currents and wind waves, so areas located adjacent to land masses and away from navigation channels are preferred. In the case of physical failure of an eelgrass enhancement site (e.g., movement of sediment offsite), navigation areas could be affected by sediment disposition and shoaling of navigation channels.

Unvegetated Shallow Subtidal

The habitat requirements for unvegetated shallow subtidal habitat are similar to eelgrass beds. Potential impacts to transportation and navigation are expected to be similar to those described above for eelgrass habitat.

Intertidal Mud/Sand Flats

Mud and sand flats are found in areas protected and unprotected from wind-driven waves and high currents. This habitat type is most likely to be created in areas protected by land masses where conditions are more favorable to habitat enhancement (e.g., within estuary channels, behind spits). Significant impacts to navigation are not expected in these areas. If this habitat type is created near existing navigation channels or deep-water areas, physical failure of the site could lead to navigation impacts (e.g., sediment deposition and shoaling in the navigation channels).

Salt Marsh

Salt marshes are found in protected and less protected areas of San Francisco Bay, although physically well-protected areas provide the most favorable conditions for habitat enhancement. Impacts to navigation are similar to those for mud and sand flats.

Islands for Bird Use

Impacts to navigation from roosting/nesting islands depend on water depth. Islands constructed in deep water or navigation areas would mostly likely impact navigation. Most shallow-water areas are not primary navigation areas, so construction of islands in these areas would generally not impact navigation.

6.5 AIR QUALITY

Air pollutant emissions would be generated during the habitat creation process by

- Dredge equipment used to obtain the new material (e.g., hydraulic dredges, hopper dredges, bucket dredges, support vessels, survey boats, etc.);
- Tugs and/or pipelines used to transport the dredged material; and
- Other equipment used to unload and distribute the dredged material.

The two primary factors that would determine the amount of emissions generated would be the total cubic yards (cy) of material required and the distance (miles) between the dredge site and habitat creation site. Emission factors based on the amount of material and distance between sites are developed and compared in the sections below for each of the three activities involved, i.e., (1) dredging, (2) transport, and (3) loading/unloading/distribution. The significance of potential impact is also discussed.

Dredging

There are three main types of dredges: hydraulic pipeline types (cutterhead, dustpan, plain suction, and sidecaster), hopper dredges, and bucket/clamshell dredges. The selection of dredging equipment and the method used to perform the dredging depends on the following factors (USACE and EPA 1992):

1. Characteristics of the material to be dredged (the quantity and quality, including the level of contamination);

2. Dredging depth;

3. Physical environment at the dredging and placement areas, and in between these two areas;

4. Distance to placement area(s); and

5. Method of placement.

Hydraulic Dredges

A hydraulic dredge works like a vacuum cleaner. It has an electrically driven pump, a ladder (an "A frame") that extends down to the sediment to be dredged, and a rotating cutter head that loosens material on the bottom. Sediment is sucked up through an intake pipe, through the pump to a discharge pipe. For intake pipes greater than 15,000 feet (4,570 m) long, booster pumps are required. Pipelines can be either floated on pontoons or submerged and anchored. Submergence would be required to keep navigation lanes open across the pipeline route, or to avoid the stresses of severe surface wave conditions on a floating pipeline. Compared to other types of dredges, hydraulic dredges result in a large volume of water in the slurry. The amount of water can increase the sediment/water volume by 50 to 100 percent. This increase in volume is called a "bulking factor," and is expressed as a ratio of post-dredged sediment/water volume to pre-dredged sediment/water volume. The hydraulic dredge bulking factor is estimated at 1.6.

Hydraulic dredges are commonly used for open water placement along the shore, with the "fill" usually resulting in a seaward extension of the existing shoreline. Upon discharge, the coarse material quickly settles out of suspension and accumulates on the bottom, while finer materials stay in suspension longer and are usually carried by prevailing currents to adjacent shores before settling.

Hopper Dredges

Hopper dredges are self-propelled seagoing ships from 180 to 550 feet (55 to 168 m) in length. They are equipped with propulsion machinery, sediment containers (hoppers), dredge pumps, and other special equipment. These dredges have power adequate for required free-running speed, dredging against strong currents, and excellent maneuverability for safe and effective work in rough, open seas. Dredged material is loosened from the channel bottom by "dragarms," sucked up by a hydraulic dredge pump, and discharged into hoppers built in the vessel. When they get to the placement site, some hopper dredges are capable of dumping the sediment out through their bottom (e.g., from split-hulled barges). Hopper dredges are classified according to hopper capacity: large-class, ocean-going dredges have hopper capacities of 6,000 cy or greater; medium-class dredges have hopper capacities of 2,000 to 6,000 cy; and small-class dredges have hopper capacities of 500 to 2,000 cy. During dredging operations, hopper dredges can dredge in depths of 10 to 80 feet (3 to 24 m) (COE/EPA 1992). A 1.2 bulking factor is estimated for this dredging method.

Hopper dredges are used mainly for maintenance dredging in exposed harbors and shipping channels where traffic and operating conditions rule out the use of stationary dredges. Hopper dredges are most efficient in excavating loose, unconsolidated sediments (COE/EPA 1992). Placement using hopper dredges is typically performed in the nearshore environment (beach nourishment) or at an ocean disposal site.

Bucket/Clamshell Dredges

A bucket or clamshell dredge is so named because it uses a bucket or clamshell-type device to excavate the dredged material. In contrast to hydraulic dredges, bucket/clamshell-dredged sediments remain in fairly large consolidated clumps and reach the bottom in this form when disposed. The effective working depth is limited to about 100 feet (30 m) (COE/EPA 1992). Part of the material in the bucket is washed away due to turbulence as each load is hoisted to the surface. To minimize the turbidity generated by a clamshell operation, watertight buckets have been developed; the edges seal when the bucket is closed, and the top is covered to minimize loss of dredged material. A 1.2 bulking factor is estimated with this dredging method.

Bucket dredges can be used to excavate most types of materials except for the most cohesive consolidated sediments and solid rock. They are effective while working near bridges, docks, wharves, pipelines, piers, or breakwater structures because they do not require much area to maneuver, and there is little danger of damaging other structures because the dredging process can be controlled accurately (COE/EPA 1992). A clamshell dredge typically places the scooped material into a barge that, when fully loaded, is towed by a tug to the disposal site. Clamshell dredges may also be used to directly place material into either trucks for subsequent disposal at an upland site (landfill or confined disposal facility), or into an adjacent contained aquatic disposal site for fastland creation.

Typical characteristics of various types of dredges that would be used in the San Francisco Bay are provided in Table 6.5-1. The characteristics of the support vessels and survey boats that are generally associated with dredging operations are also provided in Table 6.5-1.

Transport

Transportation of the dredged material from the dredge site to the placement site (habitat creation site) would depend on the type of dredging method(s) employed and the distance between the two sites. Material dredged by a hydraulic dredge can be pumped by pipeline directly to the placement site if the distance is only a few miles or less. Booster pumps would be required to supplement the hydraulic dredge pump for distances beyond a few miles (approximately one booster pump for each 0.5 - 1.0 mile beyond the first 2 miles). For sites located greater than approximately 5 miles apart, the hydraulic dredge would pump material directly into barges that, when loaded, would be hauled by diesel tug to the placement site. Hopper dredges transport the material directly to the placement site after filling their hoppers. At the placement site the material

Table 6.5-1. Characteristics of Dredges and Dredging Support Vessels [a]

Equipment Type	*Horsepower (Hp)*	*Load Factor [b]*	*Fuel Use Rate (Gal/Hr)*	*Production Rate (cy/Day)*	*Hours Per Day*	*Fuel Use Rate (Gal/1,000 cy)*
Hydraulic Dredge	2,400	0.75	119	31,200	20	76.3
Hopper Dredge	2,000	0.75	99	4,000	12 [c]	297

Clamshell Dredge	1,800	0.80	95	5,000	16	304
Support Vessel	250	0.80	13.2	NA	12	158 [d]
Survey Boat	100	0.80	5.3	NA	12	63.6 [d]

Notes:

a. Characteristics are typical average values for equipment that would operate in the San Francisco Bay.

b. Load factor is for full working conditions.

c. Hours for the Hopper Dredge are dredging hours to reach capacity only and do not include time required for transport and disposal of the material.

d. Fuel use rate for this equipment is in units of gallons per day.

NA = not applicable

would be either bottom-dumped or pumped out, depending on the design of the hopper dredge. Bucket/clamshell dredges would load the dredged material onto barges for transport by diesel tug. Characteristics of the booster pump engines, hopper dredge propulsion engines, and tugs that would be used to transport dredge material are provided in Table 6.5-2.

Unloading/Distribution

Barges loaded with dredge material are unloaded by various methods, depending upon the placement site. At open water sites the barges may be bottom-dumped directly onto the site. Or, at open water sites where there are concerns about turbidity, it may be necessary to unload the barge with another clamshell dredge. At nearshore sites, barges are typically unloaded by either clamshell dredge or are pumped out through a pipeline. One or more booster pumps would be required if the pipeline distance exceeds approximately 2 miles. At placement sites where unloading is done aboveground, a crawler dozer may be used to spread the material. Characteristics of the clamshell dredges, pump engines, and crawler dozers are provided in Table 6.5-3.

Emission Factors

Emission factors in units of pounds per 1,000 gallons of fuel burned are shown in Table 6.5-4 for the equipment used to dredge, transport, and unload/distribute material for a new habitat site. Using the information from Tables 6.5-1, 6.5--2, and 6.5–3, these emission factors are converted to units of either

- Pounds of pollutant per 1,000 cy of material dredged,
- Pounds of pollutant per nautical mile (Nm) transport distance between dredge site and placement site, or
- Pounds of pollutant per day so that the impact of some typical dredge/transport/disposal scenarios can be compared.

Table 6.5-2. Characteristics of Equipment Used to Transport Dredged Material [a]

Equipment Type	*Horsepower (Hp)*	*Average Load Factor [b]*	*Fuel Use Rate (Gal/Hr)*	*Average Speed [c] (Knots)*	*Hours Per Day*	*Fuel Use Rate (Gal/Nm)*
Booster Pump	2,100	0.70	97	NA	20	1,940 [d]
Hopper Dredge	2,200	0.75	116	9.0	NA	14.5
Tugboat	1,800	0.50	59.4	6.25	NA	9.5

Tugboat	800	0.50	26.4	4.35	NA	6.1

Notes:

a. Characteristics are typical average values for equipment that would operate in the San Francisco Bay.

b. Load factor for booster pump is for full working conditions. Average load factor for hopper dredge based on factors of 0.80 when traveling while loaded and 0.70 when traveling while unloaded. Average load factor for tugs based on load factors of 0.80 while traveling with loaded barge and 0.20 while traveling with unloaded barge.

c. Average speed for hopper dredge based on speeds of 10 knots when traveling while loaded and 8 knots when traveling while unloaded. Average speed for 1,800 Hp tugs based on speeds of 7.0 knots while traveling with loaded barge and 5.5 knots while traveling with unloaded barge. Average speed for 800 Hp tugs based on speeds of 5.0 knots while traveling with loaded barge and 3.7 knots while traveling with unloaded barge.

d. Fuel use rate for this equipment is in units of gallons per day.

NA = not applicable

Nm = nautical mile

Table 6.5-3. Characteristics of Equipment Used to Unload and Distribute Dredged Material [a]

Equipment Type	*Horsepower (Hp)*	*Load Factor [b]*	*Fuel Use Rate (Gal/Hr)*	*Production Rate (cy/Day)*	*Hours Per Day*	*Fuel Use Rate (Gal/1,000 cy)*
Clamshell Dredge	1,800	0.80	95	5,000	16	304
Booster Pump	2,100	0.70	97	NA	20	1,940 [c]
Crawler Dozer	140	0.59	5.5	NA	12	66.0 [c]

Notes:

a. Characteristics are typical average values for equipment that would operate in the San Francisco Bay.

b. Load factor is for full working conditions.

c. Fuel use rate for this equipment is in units of gallons per day.

NA = not applicable

Dredging Scenarios and Comparison of Emissions

A quick comparison of the amount of emissions that would be generated by use of the various dredging methods can be made by setting up a similar scenario for dredge/transport/disposal for each. In each case, 100,000 cy of material would be dredged, transported a distance of 5 Nm, and unloaded and distributed at a new habitat creation site.

- Case No. 1 would include a <u>hydraulic dredge</u>, support vessel, survey boat, pipeline with four booster pumps, and a D-6 dozer.

- Case No. 2 would include use of a <u>hopper dredge</u>, support vessel, survey boat, and a D-6 dozer.

- Case No. 3 would include use of a <u>clamshell dredge</u>, support vessel, survey boat, 800 Hp tug, and a D-6 dozer.

The daily and total emissions associated with each of these cases are summarized in Table 6.5-5.

Table 6.5-5 indicates that for a scenario of dredging / transporting / disposing an equivalent amount of material at the same site, the total emissions of nitrogen oxides (NO_x), sulfur dioxide (SO_2), and particulate matter less than 10 microns in diameter (PM_{10}) would be approximately the same regardless of the type dredge used, i.e. hydraulic, hopper, or clamshell. The clamshell dredge produces more carbon monoxide (CO) emissions than the hopper dredge, and the hydraulic dredge produces less. However, the booster pumps used with the hydraulic dredge produce a lot of CO which, when added to the hydraulic dredge emissions, would cause the total CO emissions to be greater than for the hopper dredge case.

Table 6.5-4 Emission Factors for Equipment Used to Dredge, Transport, Unload, and Distribute Material for a Habitat Creation Site

Table

6.5-5 Daily and Total Emissions Associated with Three Similar Cases for Dredge, Transport, and Disposal of 100,000 cy of Material

Reactive organic gas (ROG) emissions would be greatest for the dredge scenario using the hopper dredge. ROG emissions from the clamshell dredge and hydraulic dredge cases would be approximately 3 to 5 times less, respectively. Daily emissions of all pollutants would be greatest for the hydraulic dredge scenario. However, this is due to the much higher daily production rate of the hydraulic dredge (see Table 6.5-1), so total work days would thus be significantly less than for the cases where either a hopper or clamshell dredge is used.

Significance of Emissions

As indicated previously, the selection of dredging methods and equipment will largely be dictated by the characteristics of the dredge and placement sites and the distance between them. Regardless of the final selection, the emissions generated during the dredge/transport/ placement activity would be considered as construction-related emissions and, as such, would not be considered a significant impact. With respect to emissions from construction activities, the BAAQMD recommends that lead agencies focus on avoidance of significant impacts through the implementation of control measures for PM_{10}, which the BAAQMD considers to be the pollutant of greatest concern from construction activities (BAAQMD 1996). Accordingly, if applicable PM_{10} control measures are included as part of project construction, the impact is considered less than significant by the BAAQMD.

Potential Effects on Climate Change

The creation of shallower water by the proposed habitat/enhancement projects would tend to isolate these areas from the effects of the adjacent Bay waters and subject these areas to greater influence by atmospheric conditions, compared to the existing influences on water depths not affected by such projects (referred to here as "no-action" depths). Conduction of warmer air during the summer months would warm these shallower waters. In addition, solar energy would be more likely to penetrate to the Bay bottom and increase the temperature of the overlying water column. During the colder months of the year, conduction of colder air would generally outweigh the effect of increased bottom warming and would produce colder water compared to no action depths. Creation of new land areas would increase the temperature of the overlying air during the warmer months of the year due to solar heating of the land masses. These new land areas would decrease the overlying air temperature during the cooler months due to radiational cooling effects. To a lesser extent, the changes in water temperatures mentioned above would also produce a corresponding affect on air temperatures. The change in air temperature and creation of new lands could produce minor changes in humidity and possibly the formation of low clouds at the project sites. However, these effects are expected to be limited to the immediate site locales, would not cause substantial changes in the localized area climate, and would have no effect on the larger-scale Bay Area climate.

6.6 LAND/WATER USE

Land use or water use impacts would be potentially significant if dredged material placement resulted in a change that would alter or displace a previous land or water use to a degree that the previous use was no longer possible.

Except perhaps in the case of creation of islands for bird use, dredged material placement would not result in a new land use. Creation of shallow-water habitat could displace recreational boating in a limited area if the shallower depth were insufficient for boat passage or if the area were declared off limits to boating. On the other hand, creation of shallow-water habitat could improve fishing and may improve other environmental amenities that many recreational boaters appreciate, such as abundance of birds and other wildlife.

In the South Bay and in San Pablo Bay, where space is relatively abundant and recreational boating is not as heavy as it is in the central portion of San Francisco Bay, a minor reduction of boating area would be a less than significant impact.

In the central portion of the Bay, creation of shallow-water habitat in locations, such as unused harbors that are not accessible for recreation, could improve the recreational boating experience. In some locations, however, a reduction of boating area could be an adverse impact due to the generally crowded situation in the central portion of the Bay, although this would need to be determined on a site-specific basis.

6.7 NOISE

The primary consideration for noise impact assessment is the annoying or intrusive effect of noise. Land use compatibility guidelines from local general plans or regulatory thresholds established by state and local codes generally provide the criteria used to judge the significance of noise impacts. These guidelines and codes, however, are typically designed to apply to land areas, not water areas.

Except perhaps in the case of creation of islands for bird use, dredged material placement would not result in a new land use. After the construction phase is complete, ambient noise levels would be unchanged. Hence, the potential noise impacts would be a temporary intrusion.

For the purposes of this evaluation, it is assumed that project-generated construction noise levels would be considered significant if construction-related noise would affect noise-sensitive land uses (residential, medical, educational, or passive recreational land uses) and would result in an overall noise level exceeding 65 dBA.

The noisiest part of dredged material placement at a water placement site is the tugboat that maneuvers the barge. Tugboats typically generate a noise level of about 82 dBA (L_{eq}) at a distance of 50 feet. With a noise attenuation rate of 5 dBA for each doubling of the distance over water (see section 4.2.7), the noise level of the tugboat would be less than 65 dBA at a distance of 600 feet (200 yards). Most of the potential ROI, however, is well in excess of 200 yards from any land area, hence, in most locations the potential noise impact would be less than significant.

If, however, the dredged material placement site is within 200 yards of a noise sensitive receptor on land, the noise impact could be potentially significant and may require mitigation.

Mitigation Measures

- Acceptable mitigation of noise impacts may include limitation of the hours of disposal operations or erection of temporary noise barriers.

6.8 SUMMARY OF BENEFITS AND IMPACTS OF HABITAT CREATION/ ENHANCEMENT

Table 6.8-1 summarizes the potential benefits and impacts of habitat creation/enhancement projects. Since the purpose of such habitat projects is to provide beneficial impacts (otherwise they would not be implemented), the table reflects that the beneficial impacts are the *intended* beneficial effects of habitat projects. Adverse impacts are broken down into short-term impacts associated with the construction of the project, and long-term impacts. Since a habitat project would not likely be implemented if long-term impacts were predicted at the outset, the table reflects that such long-term impacts would be *unintended* adverse effects or the effects of projects that failed to achieve their habitat goals, for whatever reason.

Table 6.8-1. Summary of Potential Beneficial and Adverse Impacts of Habitat Creation/Enhancement

Resource Area	Beneficial Impacts (Intended Effects of Habitat Projects)	ADVERSE IMPACTS	
		Short-term (Construction) Impacts	Long-term Impacts (Unintended Effects or Effects of Project Failure)
Biological Resources	Enhancement of existing habitat and corresponding biological community to a habitat and community that is more diverse, productive, or that supports important target species such as the California least tern and clapper rail, salmonids, herring, smelt, etc.	Localized and temporary effects on plankton, aquatic plants, fish, birds, and marine mammals associated with increased turbidity during disposal operations. Disruption of the benthic community and temporary, localized effects on fish, bird, and marine mammal foraging success until recolonization of benthic community occurs. Temporary noise disturbance and associated avoidance behavior observed in fish, birds, and marine mammals.	Loss of existing habitat and possible creation of new habitat that is not as productive, does not support important target species, or does not have a net benefit over the existing habitat, particularly should the enhancement project fail (i.e., a net loss of ecological value). Possible introduction or spread of exotic species into areas that previously were dominated by native species. Possible creation of habitat for unwanted species not exotic (e.g., new perches on habitat island for hawks to use to hunt clapper rail and marsh mice).
Water Quality	None.	Localized and temporary effects on some water quality parameters (temperature, dissolved oxygen, TSS, nutrients, metals and organic chemicals).	Possible creation of poor water quality conditions for some water quality parameters (temperature, dissolved oxygen, TSS, nutrients, metals and organic chemicals) due to hydrodynamic effects.
Hydrodynamics	None.	Localized and temporary adverse effects on water movement patterns.	Possible creation of poor flushing conditions; altered sedimentation or erosion patterns.
Transportation and Navigation	None.	Temporary interference with navigation of small craft or major shipping lanes if project is close to navigable areas.	Altered sedimentation/erosion could cause shoaling of navigation channels. Projects adjacent to channels or in areas of boat traffic could create a new navigation hazard.
Air Quality	None.	With implementation of applicable BAAQMD control measures for PM10, impacts would be considered less than significant.	None.
Land/Water Use	Creation of shallow-water habitat could improve fishing and other environmental amenities, such as abundance of birds and wildlife, appreciated by recreational boaters.	Construction of shallow-water habitat could displace recreational boating if the construction area were off limits or posed hazards to boating. In the central portion of the Bay, any reduction of boating area would be considered an adverse impact.	Creation of shallow-water habitat could displace recreational boating if the shallower depth were insufficient for boat passage or if the area were off limits to boating. In the central portion of the Bay, any reduction of boating area would be considered an adverse impact.
Noise	None.	Potential short-term noise impact if dredged material disposal site is within 200 yards of a noise sensitive receptor.	None.

7.0 ALTERNATIVES

Alternatives to placing dredged material in the Bay for habitat creation or enhancement under the proposed Bay Plan Amendment include (1) the no-project alternative (i.e., consistent with present disposal practices and policies), (2) a less restrictive Amendment policy than that proposed, and (3) a more restrictive Amendment policy than that proposed.

The no-project alternative would mean a continuation of existing dredging policies and dredged material management practices. Existing dredged material management practices include placing dredged material in the Bay only at designated in-Bay disposal sites, placing the material at upland sites, or ocean disposal of the material at the San Francisco Deep Ocean Disposal Site (SF-DODS). The four designated in-Bay disposal sites include Alcatraz (SF11), San Pablo (SF10), Carquinez Strait (SF9), and Suisun Bay. (Note that the no-project alternative (i.e., existing policies) does not preclude placement of dredged material in the Bay for beneficial reuse provided there are no feasible upland or ocean reuse/disposal sites.) Upland options for dredged material reuse include habitat (e.g., wetland) restoration, levee maintenance (e.g., in the Delta), and sediment rehandling facilities. The impacts of all these disposal practices are described at a programmatic level in the EIS/R on the LTMS (Long-Term Management Strategy) for dredged material placement in the Bay Area (USACE et al. 1998). The no-project alternative would result in none of the benefits or impacts associated with using dredged material to create or enhance Bay habitat, as described in Chapter 6 and summarized in Table 6.8-1.

The LTMS policies on dredged material placement, analyzed in the EIS/R noted above (USACE et al. 1998), are currently being implemented by federal agencies. State agencies, however, are in the process of revising their policies to reflect the LTMS policies; the proposed Bay Plan Amendment analyzed in this document is an example of the state process. Under the LTMS policies, dredged material is expected to be placed at beneficial reuse sites faster than would occur under existing policies.

The no-project alternative could be environmentally superior to the proposed Bay Plan Amendment if habitat creation/enhancement projects prove to be failures but, with proper planning and implementation, this is not likely for most of the projects. With proper planning and implementation, Bay habitat projects using dredged material could be environmentally superior to the no-project alternative. A comparison of specific, proposed projects with the no-project alternative should be part of project-specific environmental review.

The two other alternatives noted above include a less restrictive policy on beneficial reuse of dredged material in the Bay than that evaluated in this document, and a more restrictive policy. A less restrictive policy would likely result in more adverse environmental impacts to the Bay, and thus would not be preferred over the proposed Bay Plan Amendment. A more restrictive policy would not allow the case-by-case analysis of specific proposed Bay habitat projects that have merit (this case-by-case analysis would be expected under the proposed Amendment), and thus would not be preferred over the proposed Amendment.

8.0 CUMULATIVE IMPACTS

There is a potential for habitat enhancement projects in San Francisco Bay to have both short-term and long-term cumulative impacts with other projects. These cumulative impacts could occur among multiple enhancement projects, or between enhancement projects and other types of projects in the Bay. Other potential types of in-water construction projects include dredging; dredged material disposal; in-Bay solid fills; and construction, removal or repair of piers and quaywalls.

The principal short-term cumulative impacts that could occur would result from project construction, which in the case of habitat enhancement projects entails placement of dredged material (in most cases through the water column), possibly accompanied by construction of berms or other containment structures. As described in Chapter 6, project construction would result in temporary and localized increases in TSS and related water quality impacts, with potential biological impacts as well. If multiple in-water projects (either habitat enhancement or other types of projects such as dredging) were constructed at the same time and in the same region of the Bay, it is possible that the water quality impacts of these projects could combine to result in cumulative impacts. The resulting biological impacts could be more severe or widespread than the sum of the impacts of the individual projects if these projects did not overlap in time and space. Unless a large number of projects, or projects of very large scale, overlapped in this manner, it is unlikely that cumulative short-term, construction-related impacts would be significant. However, the environmental review for each proposed habitat project should assess the potential for cumulative impacts for the specific time and location of that project.

Habitat enhancement projects could have cumulative long-term impacts with other projects that have similar long-term effects on the environment. The most obvious example of this is multiple habitat enhancement projects. If multiple habitat projects were constructed in the same part of the Bay, it is possible that some of the types of impacts described in Chapter 6 could become more significant as a result of the cumulative effects of the projects. For example, making large areas of the Bay shallower could cause significant changes in hydrodynamics, potentially resulting in reduced flushing, increased siltation, increased erosion, or other related effects. This could lead to adverse water quality impacts (temperature, TSS, DO, nutrients, etc.) as well as adverse impacts to habitats and biological communities. Making large areas of the Bay shallower could affect water and air temperatures, as well as other aspects of local climate (section 6.5). Another concern is that converting too much habitat of one type to other types could result in unforeseen ecological imbalances. For example, converting too much deep habitat to shallow habitat could affect migration corridors for fish, or reduce habitat for a life stage of an important fish or invertebrate species to the point that it becomes limiting for the population. Similar scenarios can be envisioned for converting from one type of shallow habitat to another (unvegetated to vegetated, for example), or making modifications to tidal marsh. When the potential for full or partial failure of habitat projects is considered, the potential for adverse cumulative impacts from multiple projects is increased. Multiple or large-scale habitat conversions may also facilitate the establishment or spread of non-native invasive species. It will be important, therefore, that the analysis of both project-specific and cumulative impacts for each proposed project take into account these types of potential interactive effects.

It is less likely that projects other than habitat enhancement projects would have cumulative long-term impacts with habitat projects. This is because few other types of projects have long-term environmental impacts that are similar to those of habitat enhancement projects. Because of restrictions on filling in the Bay, the potential for non-habitat projects to result in significant "shallowing" of the Bay is very small. However, large in-Bay fill projects (e.g., the proposed expansion of San Francisco International Airport) could combine with in-Bay habitat projects to cumulatively have significant adverse impacts. It is conceivable that a large dredging project could have cumulative hydrodynamic impacts with a large habitat project, although the two projects would have opposite effects on water depth. However, the likelihood of a large deepening project being approved in the Bay in the foreseeable future is also small. Nevertheless, the analysis of each proposed habitat enhancement project should consider the potential for cumulative impacts with non-habitat projects.

9.0 RECOMMENDATIONS

In order to determine if future, specific proposed Bay habitat projects are worth pursuing, a number of site-specific studies would be needed. Projects should only be approved that show significant benefits over existing conditions. The following is a list of recommendations, excerpted from this report, for site-specific studies to evaluate the suitability of any proposed Bay habitat enhancement or creation project using dredged material.

- An evaluation of site-specific and project-specific environmental impacts that cannot be predicted now at a programmatic level.
- Detailed site-specific environmental analysis evaluating the expected habitat benefits and losses from a proposed project, where an objective analysis concludes that a significant net biological benefit is expected to result from the project. This analysis would also evaluate the risk of not achieving those benefits. For example, converting an eelgrass bed, tidal marsh, or mudflats — generally biologically productive habitats — to some other habitat may not result in a net biological benefit.
- Studies to determine what would be expected to cause physical failure at a specific site (e.g., physical failure meaning where the placed sediments do not remain in place, or the desired physical features such as elevation and slope are not maintained over time), and any measures needed to prevent or mitigate potential failures, to maximize the likelihood of the expected biological benefits from the project.
- Evidence of proper site selection and design to ensure that, when converting to a shallower area, the following adverse impacts related to changing the local hydrodynamics (i.e., reducing circulation and flushing) are not expected to occur:
    - Dissolved oxygen levels do not decrease below water quality objectives;
    - Nutrient concentrations do not increase above water quality objectives; and
    - Metals and organic chemical concentrations do not increase above water quality objectives.
- Evaluation of any existing local input of contaminants to the proposed habitat site.
- Identification of construction methods that will effectively achieve the project's design specifications, and control turbidity during the placement of the dredged material at the site.
- Site-specific analysis of the existing benthic community at the proposed enhancement site, and an evaluation of the potential for invasive species to be introduced.
- Evaluation of site-specific impacts on navigation and recreational use of the project area.
- Identification of the project's goals, performance standards to measure the extent to which the project's goals are achieved, long-term monitoring requirements, and an adaptive management approach.
- Consideration of how the proposed project would affect the mix of habitat types in the Bay.

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12.0 ACRONYMS

ARB	California Air Resources Board
ATC	Authority to Construct permit
BAAQMD	Bay Area Air Quality Management District
BACT	best available control technology
BCDC	San Francisco Bay Conservation and Development Commission
CAA	Federal Clean Air Act
CAAQS	California Ambient Air Quality Standards
CCAA	California Clean Air Act
CDFG	California Department of Fish and Game
CDMG	California Division of Mines and Geology
CEQA	California Environmental Quality Act
cy	cubic yards
DDT	dichlorodiphenyl-trichloroethane
EPA	U.S. Environmental Protection Agency
IMO	International Maritime Organization
mg/L	milligram per liter
MHEA	Middle Harbor Enhancement Area
MHHW	mean higher high water
MLLW	mean lower low water
NAAQS	National Ambient Air Quality Standards
Nm	nautical mile
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxides
O_3	ozone
PAH	polyaromatic hydrocarbons
PCB	polychlorinated biphenyls
PM_{10}	particulate matter smaller than 10 microns in diameter
$PM_{2.5}$	particulate matter smaller than 2.5 microns in diameter
PPD	Pollutant Policy Document
ppm	parts per million
ppt	parts per thousand
PTO	Permit to Operate
RMP	Regional Monitoring Program
RNA	Regulated Navigation Area
ROG	reactive organic gases
ROI	region of influence
RWQCB	Regional Water Quality Control Board
SFBAAB	San Francisco Bay Area Air Basin
SFEI	San Francisco Estuary Institute
SIP	State Implementation Plan
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SO_2	sulfur dioxide
SWRCB	State Water Resources Control Board
TBT	tributyltin
TOC	total organic content
TSS	total suspended solids

$\mu g/m^3$	micrograms per cubic meter
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compounds
VTS	Vessel Transportation Service
WQGs	water quality guidelines

Figure

1 The Planning Area for the Bay Plan Amendment

Figure 1, page 2

Figure

2 Relationship between Average Current Velocity and Sediments of Uniform Texture Showing Velocities Necessary for Erosion, Transportation, and Deposition

Figure 2, page 2

Figure

3 Bathymetry, Channels, Sediment Types, and Tidal Marshes in the San Francisco Bay Area Overall

Figure 3, page 2

Figure

4 Bathymetry, Channels, Sediment Types, and Tidal Marshes in the South Bay

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Figure

5 Bathymetry, Channels, Sediment Types, and Tidal Marshes in the Central Bay

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Figure 6 Bathymetry, Channels, Sediment Types, and Tidal Marshes in San Pablo Bay

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Figure 7 Bathymetry, Channels, Sediment Types, and Tidal Marshes in Northeastern San Francisco Bay

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Figure

8 Eelgrass Beds in San Francisco Bay

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Figure

9 Typical Vessel Traffic Routes in the Planning Area

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Figure

10 San Francisco Bay Area Air Basin